

Forest Products Research 1961

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DEPARTMENT OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

FOREST PRODUCTS
RESEARCH
1961

*Report of the Forest Products Research
Steering Committee
with the
Report of the Director of
Forest Products Research*

LONDON
HER MAJESTY'S STATIONERY OFFICE
1962

FOREST PRODUCTS RESEARCH
STEERING COMMITTEE

1961

Chairman: B. K. BLOUNT, Esq., C.B., D.Phil.Nat., F.R.I.C.
A. C. COPISAROW, Esq., D.Sc., F.Inst.P., A.M.I.E.E.,
F.I.W.Sc.
Professor M. V. LAURIE, O.B.E., M.A., Dip.For.
L. J. CARDEW WOOD, Esq., B.Sc., A.C.G.I.,
M.Inst.C.E., M.I.Mech.E., A.F.R.Ae.S.
H. WOOLDRIDGE, Esq., O.B.E., B.Sc.

Secretary: R. EDMONDS, Esq.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
State House, High Holborn,
London, W.C.1.

CONTENTS

	PAGE
REPORT OF THE FOREST PRODUCTS RESEARCH STEERING COMMITTEE FOR 1961	1
REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR 1961	3
General	3
Co-operation	4
Advisory Work	6
Educational Activities	6
Visitors	7
Exhibitions	7
Publication	7
Staff Changes	9
PROGRAMME OF RESEARCH	9
DIVISION A (Science)	9
Wood Structure	9
Collection of Timber Specimens	9
Home-grown Timber Investigations	10
Chemistry	11
Wood Analysis	11
Wood Polysaccharides	12
Wood Extractives	12
Physics	13
Density Determination	13
Diffusion of Water Vapour in Wood	13
Elasticity of Wood	14
Pulp and Paper	14
Factors Affecting Reproducibility of Results	14
Sulphite Cooking of Sitka Spruce	14
Lodgepole pine	15
Effect of Fibre Form on Pulp Properties	15
Wood Preservation	15
Preservative Treatment of Home-grown Poles	15
The Preservative Treatment of Home-grown Timbers by Diffusion	15
Methods of Estimating Preservatives in Wood	16
The Effect of Size on the Life of Timber in Contact with the Ground	17
Treatment of Home-grown Oak Fencing	18
Permeability of Wood	18
Mycology	19
Culture Collection	19
Natural Durability Tests	19
Wood Preservatives	19
Dry Rot	19
Sap Stain Investigations	20
Fungal Physiology	20
Entomology	21
Economic Problems	21
Biology, Habits and Nutrition	21
Prevention and Control of Infestations	24
Techniques	25
Collections	25

CONTENTS

	PAGE
DIVISION B (Engineering).	25
Seasoning	25
Kilns and Kiln Seasoning	25
Home-grown Timber Investigations	25
Accelerated Air-drying of Pitprops	25
Colour Changes During the Drying of Beech	26
Distortion Experiments	26
Anti-shrink Treatment	26
Wood Bending	26
Composite Wood	27
Studies of Glues and Gluing	27
Radio Frequency Heating	28
Bark Form and Veneer Figure in Birch	28
Chipboard Manufacture and Properties.	28
Timber Mechanics	29
Quality and Properties of Home-grown Timbers	29
Working Stresses	30
Laminated Construction	30
Textured Concrete	31
Sheet Materials	31
Effect of Pre-compression on Strength	31
Woodworking	32
Comparison of Tool Wear	32
Woodworking Properties	32
Stresses in Circular Saws	33
Theory of Cutting	34
REFERENCES	35
APPENDICES	
I. Staff of the Forest Products Research Laboratory, 31st December, 1961	37
II. List of Publications Issued During 1961	40
III. List of Common Names Cited in the Text	42
INDEX	44

LIST OF ILLUSTRATIONS

PLATES

(Inserted between pages 20 and 21)

1. The experimental machine used for compressing and bending the split Y-D type spade handle.
2. Records of density variation across individual growth rings obtained with the beta-ray equipment together with photomicrographs of the corresponding sections.
3. Recording temperatures in culture tubes of *Merulius lacrymans* after irradiation of an experimental wall.
4. (a) Surface of birch plywood showing exit holes caused by *Anobium* beetle. Mag. $\times 1$.
(b) Radiograph of same portion showing active larvae. The dark shadows are tunnels.
5. Small scale plant for chipboard manufacturing. From left to right—screen, conditioner, pendulum for examining spray-gun pattern, tumbler, split box for mat forming.
6. A structural design to demonstrate the use of home-grown softwoods in straight and curved laminated construction.
7. Appearance of textured concrete resulting from the use of home-grown Douglas fir shuttering.
8. Pattern of cutter wear after machining along a glue line:— (a) moderate glue, (b) abrasive glue, (c) very abrasive glue. Mag. $\times 130$.

FIGURES

	PAGE
1. Specimen card for the microscope key for the identification of hard-woods	8
2. Average distribution of boron in samples of Sitka spruce	16
3. Effect of thickness on the life of various timbers in the ground	17
4. Occurrence of <i>Hylotrupes bajulus</i> in relation to daily maximum temperatures in August	22
5. Tangential stresses in a circular saw	33

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REPORT OF THE FOREST PRODUCTS RESEARCH LABORATORY STEERING COMMITTEE FOR 1961

To the Council for Scientific and Industrial Research

IN our report last year we looked forward with some confidence to much closer relations with other organizations concerned with timber, and in particular, to the formulation of joint research projects utilizing the special facilities and long experience available in the Laboratory. It is with especial pleasure, therefore, that we record two important developments in this direction during 1961. In the international field, a most promising start has been made in the formulation of a collaborative programme of work with the corresponding laboratories in the four Scandinavian countries—Denmark, Finland, Norway and Sweden. The Director of the Laboratory visited Scandinavia early in the year, and there has since been an interchange of specialists. A member of the staff of the Norwegian Laboratory has joined the Composite Wood Section at F.P.R.L. for a nine-month study of British research methods. In October, the five Directors concerned met at the Forest Products Research Laboratory and agreed to attack several research problems in collaboration, each contributing in the field in which his Laboratory could best help. Scandinavia is a major timber-producing area; Britain is a large importer of timber, and much of it comes from Scandinavia. As this collaboration develops, as we fully intend it shall, we hope that it will be possible to correlate defects in wood with its previous history in the forests, during storage, and in shipment. This should result in benefit both to Scandinavia in its production techniques and to the U.K. in the quality of the timber received.

Collaboration between the Laboratory and British industry has also made progress during the year; a particular event has been the start of a programme of research on chipboard with financial support from the chipboard industry. A three-month pilot investigation early in the year has been followed by an agreed programme of research which will extend over the next two years. We welcome this example of enterprise in research by a timber-using industry and hope that other sections of the user industries may be inspired to follow.

A subject which has engaged our attention during the year, and to which we attach great importance, is the need to make the experience and knowledge of the Laboratory more readily available to developing territories, particularly those within the Commonwealth. Through the new Department of Technical Co-operation, we are already providing some assistance of this type. One officer of the Laboratory is spending a year in Nigeria helping to develop the newly established timber research Laboratory, another will shortly be in Nigeria for 18 months to advise on entomology; and we have been pleased to welcome three Nigerian research workers in the Laboratory for periods of nine months each. There is much that could be done to help other countries in this way and we hope to see this pattern of activity further developed.

During the year we considered the probable development of the programme of work of the Laboratory until 1967. We foresee the need for a continuing increase in the effort to be made available, and expect that this will be deployed mainly in three ways: in expanding the more basic and longer-term research work of the Station, in developing the work necessitated by the rapid growth of home-grown timber production, and particularly in increasing the effort on problems of immediate practical importance to industry and the liaison, advisory and other activities aimed at securing the use of the results of research in industry. Already we have been encouraged by the great increase in the number of visitors to the Laboratory referred to in the Director's report. As an indication of a growing awareness of the work of the Laboratory, this augurs well for the future.

B. K. BLOUNT

Chairman

January, 1962

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR 1961

GENERAL

SPECIAL attention has been directed during the year under review to examining new ways in which the Laboratory could assist in fostering the shorter term economic growth of the country. Part of the Research Programme has been re-orientated for this purpose and results obtained have been more widely disseminated.

Industry in particular has shown a substantially greater interest than in recent years. Compared with last year, for example, the total number of technical enquiries received by the Laboratory has increased by 65 per cent, the number of visitors has almost trebled, and the contribution to the Laboratory's income provided by industry for co-operative research has also trebled. It is a trend which accords with a prime function of the Laboratory, namely, to assist industry to undertake more research for itself and so eventually raise its productivity.

As the basic Research Programme has not been diminished and the staff complement has remained virtually constant, the resources for new activities have been found by such means as:—

- (a) abbreviating or, in a few cases, suspending further work on prolonged projects now beginning to show diminishing returns;
- (b) re-organizing the staff so that eleven specialist sections merge into two main Divisions in order to obtain greater flexibility and encouraging marginal and hybrid studies; and
- (c) using a newly established Intelligence Section, one of whose functions is to help increase efficiency by relating the programme of the Laboratory more closely to the activities of other organizations.

The problem which continues to receive the greatest proportion of the Laboratory's attention is the more productive use of the country's natural resources of timber. A part of the Engineering programme and three specific studies have this requirement in view. Methods of combating or avoiding damage due to fungi and an ambrosia beetle, which attack and degrade newly felled timber, are being investigated in collaboration with the Forestry Commission. Secondly, methods are being studied of carrying out a combined seasoning and preservative treatment on home-grown Scots pine suitable for telegraph or transmission poles. Thirdly, in the pulping of home-grown timbers, work is being concentrated on determining the relative suitability of different softwoods for pulping by a high yield process to give a bleached paper.

Certain of the projects completed during the year have provided results of immediate practical application. Thus, the basic investigation on compression-relaxation phenomena in stressed wood has shown that some residual strain is retained which permits the bending of wood to a relatively small radius in the cold state. This has led the Seasoning Section to patent a new process for the manufacture of implements such as Y-D spade handles having far fewer

failures than the traditional method. Another new process of special interest to builders and architects has been completed. Their wish to use timber shuttering to impart a texture to the exposed surfaces of concrete cast *in situ* has presented some difficulty, particularly in the absence of adequate supplies of figured boards. The Laboratory's technique will enable boards with a prominent figure to be produced from sawn home-grown softwood. Comprehensive data on stress values for both solid and laminated timber have been published during the year and their wider dissemination should help to promote safety, enable timber to be used more economically, and contribute towards the extended use of timber engineering structures.

New Projects

Three of the investigations which have been begun during the year are of considerable scientific interest. They are:

- (a) The relationship between the distribution and chemical form of nitrogen in the tree and the nutritional requirements of the common furniture beetle in order to explain why the larvae of this insect develop better in nitrogen-rich wood.
- (b) The anatomical features of superior specimens of home-grown species in order to determine which desirable characteristics are inheritable and how far they are influenced by growth conditions.
- (c) The influence of morphological, chemical and physical properties of softwood fibres on pulp quality.

The first of these studies may, in addition, indicate a technique for culturing the pest with a shortened life-cycle for laboratory purposes, whilst the second and third should prove of value to the Forestry Commission in their long-term planning.

An important new project has been begun in collaboration with British chipboard manufacturers. At present this work is mainly fundamental in character, being concerned with moisture relations and glue bond factors, but the successful completion of the project should ultimately lead to an improved industrial product, to economies in plant operation, and to better use being made of the raw materials. Another long-term project on adhesives has been started in collaboration with, and with the financial support of, members of the British Plastics Federation.

(a) In Britain

CO-OPERATION

In addition to the full and close collaboration that has been maintained with the Forestry Commission, joint studies have been pursued with other organizations. A project has been initiated in conjunction with the United Kingdom Atomic Energy Authority to examine the possibility of improving the dimensional stability and mechanical properties of wood by impregnating with a reactive chemical and polymerizing this by radiation. In co-operation with the Medical Research Council Unit for Research on Experimental Pathology of the Skin, a preliminary investigation has been begun on the irritant action of certain timbers.

The Laboratory continues to be represented on many British Standards Committees, giving assistance in the drafting and revision of Standards and Codes of Practice. The former Composite Wood Research Panel and the Radio Frequency Panel have been merged into a single Composite Wood Panel which provides a valuable forum for the discussion of the Laboratory's plywood and glue programme to ensure both that the views of industry are

fully known at the programme formulation stage and that the results achieved are as widely and quickly available as possible. The Panel system has proved so successful in this case that it is planned to make similar arrangements or hold small conferences in the wood protection, wood cutting and possibly other fields.

Close contact has been maintained with the Building Research Station on structural problems and, after the flooding in south-west England, on appropriate measures for the drying out of houses; also with the National Engineering Laboratory on the principles of new woodcutting techniques.

Since the recent appointment of their Chairman and new Director, more frequent useful exchanges have taken place with the Timber Trade Federation and Timber Development Association respectively. Discussions now being held with them on the problem of degradation in imported softwoods could prove of distinct value in linking research with a current need of industry and the trade.

Co-operation with the Universities has become closer. Arrangements have been made to use equipment in the Chemical Departments at Edinburgh and Nottingham Universities. There have been frequent exchanges with Imperial College and the University College Dublin in the field of extractives, and with the Universities of Oxford and Bangor in wood structure. A research contract has been placed with Professor R. D. Preston, F.R.S., of the University of Leeds for research on the structure of wood as revealed by X-ray diffraction analysis and electron microscopic examination.

Assistance has been given to the B.B.C., including broadcasts in their Radio Newsreel, European, East African and Schools television programmes, and in collaboration with the Central Office of Information, a broadcast was recorded for South and Central America.

(b) *International*

Following upon a visit of the Director to the Scandinavian countries in April, the Directors of the Norwegian, Swedish, Finnish and Danish forest products research laboratories visited the Laboratory in October for joint discussions and agreed a policy of collaboration. The principal subjects of initial co-operation include the degradation of softwoods in transit, the discoloration of beech, the geographical distribution and activity of the house longhorn beetle, the effect of water storage on the permeability of wood, and methods of accelerating seasoning. Co-operation between Britain and its largest timber suppliers is of permanent importance and annual meetings between the five countries are envisaged.

Technical assistance has been given to some of the newly established timber research laboratories, and particularly to the Nigerian Government, to which, following an initial plan drawn up by Mr. A. V. Thomas, another member of the Laboratory, Mr. A. J. Comben, has been seconded for one year to assist in setting up a Forest Products Research Laboratory at Ibadan. Mr. M. G. White will shortly be seconded to Nigeria for 18 months to study methods of preventing the infestation of iroko trees by the gall bug, *Phytolyra lata*, whilst three Nigerian officers have come to England to spend nine months in the Laboratory.

At the request of the Forest Products Research Branch, Canada, visits have been made to the docks at Liverpool and Manchester to examine consignments of timber discharged from a vessel which had been delayed for four months in the Panama Canal.

Overseas visits have been made by Dr. R. H. Farmer, who attended the 18th International Congress of Pure and Applied Chemistry in Montreal, including a Symposium on Wood Chemistry and a Symposium in Chicago on the Utilisation of Lignin, and discussions at Canadian research institutes and firms. Mr. J. G. Savory has visited Sweden to discuss measures employed there for the control of blue stain in softwoods and also visited research institutions in Denmark. On seasoning problems, Mr. W. C. Stevens has had discussions at the Centre Technique du Bois and the Centre Technique Forestier Tropical in Paris. Mr. D. D. Johnston has studied the methods employed at a number of saw mills in Normandy for seasoning beech, and Mr. G. H. Pratt, whilst in the Netherlands, has had discussions at the Houtinstitut T.N.O. at Delft. Mr. J. F. S. Carruthers has attended the Hanover Fair to see chipboard and plywood machinery and has discussed chipboard problems at research institutes in Western Germany. Mr. J. G. Sunley has made a short visit to Canada and the United States in connection with stress grading and related problems in timber mechanics.

The maintenance of a high level of international co-operation in the field of forest products research is considered essential for the Laboratory and it is proposed to develop this further still during 1962.

ADVISORY WORK

The number of enquiries has increased steadily over the past year and amounted to 8508 letters of an advisory nature. The source of these requests by percentages was as follows:—

Industrial organizations	...	...	...	44	per cent
Government Departments	...	...	...	23	"
Individual members of the public	...	...	...	16	"
Associations and institutions	...	...	...	9	"
Universities, technical colleges and schools	...	...	...	4	"
Local Authorities	...	...	...	2	"
Consultants	...	...	...	2	"

Advice of the specialist staff has been sought on a wide range of topics. One interesting enquiry concerned the nature of the surface deterioration of the European oak timber of the Swedish man-of-war "Vasa", which was recently raised after lying for over 300 years in more than 100 ft of water in Stockholm harbour. Examinations have been carried out on the wreckage of a glider and on a faulty roof structure. Another enquiry has concerned a project for the sawing on a mass production basis of low grade home-grown hardwoods. A detailed study was made of the potential performance of various types of machinery and mill lay-out and specific recommendations were made for plants of different levels of production.

EDUCATIONAL ACTIVITIES

Five courses in kiln operation and seasoning have been held, attended by 54 students. The demand for the general five-day course in wood technology has grown so that seven such courses at a fairly advanced level have been held, attended by 59 visitors engaged in a wide range of timber utilization activities. The four forestry teaching Universities sent a total of 66 students to the Laboratory for two days. Imperial College sent 52 engineering students and the

University of Oxford 18 post-graduate students for sessions on their specialist interests. Overseas students from South America, South-East Asia, West Africa and Western Europe have visited the Laboratory for periods from one week up to nine months for instruction and study and one student has been trained for a period of six months as part of a Diploma in Technology Sandwich Course, at a College of Advanced Technology.

VISITORS

There has been a marked increase in the number of visitors, which may be summarized as follows:—

	1960	1961
Number of parties	18	40
Overseas visitors	76	217
Total visitors	373	1005

An informal At Home was held in July, attended by 44 invited persons representing home and overseas Government Departments, University staff and commercial and industrial organizations. Invitations on a larger scale will be issued for Open Days which are planned for next May.

EXHIBITIONS

The beta-particle density equipment described in the 1960 annual report has been shown at the Royal Society's *Conversazione*. Specimen boards demonstrating the grading of home-grown hardwoods and softwoods were shown at the Royal Show at Cambridge and the Royal Counties Centenary Show at Windsor. A structure demonstrating the use of home-grown softwoods in straight and curved laminated construction was also exhibited at the Windsor Show. A panel display setting out the Laboratory's activities was sent to Durham Technical College for their exhibition during the Commonwealth Training Week. Timber specimens and photographs have been supplied to the Central Office of Information to be shown at the German Industrial Exhibition, Berlin. In November, the D.S.I.R. stand at the Building Exhibition at Olympia incorporated a number of exhibits demonstrating the utilization of home-grown timbers. These included a model and cut-away section of a forester's bungalow, the structural parts of which had been designed on the results of the Laboratory's basic research.

PUBLICATIONS

During the year five publications, in addition to the Annual Report, have been issued through H.M. Stationery Office. *Bulletin* No. 46 "Identification of Hardwoods: A Microscope Key" will enable technologists with facilities for microscope work to identify all hardwoods of economic importance on the British market as well as a number of decorative and utility timbers now rarely available. A specimen card for use with the microscope key is shown in Fig. 1. *Bulletin* No. 47 "Working Stresses for Structural Timbers" gives safe working stresses for hardwoods and softwoods in both the green and the air-dry condition. *Special Report* No. 15 "Working Stresses for Structural Laminated Timber" gives basic stresses for a range of hardwoods and softwoods and the results of investigations on the incidence of knots and their effect on strength properties, enabling more realistic values for working stresses to be

used in the design of laminated timber structures. *Record* No. 31 "Non-Pressure Methods of Applying Wood Preservatives" describes in general terms the methods used and gives data on the absorption and penetration that can be obtained in various timbers with different types of preservative. *Leaflet* No. 47 "The Movement of Timbers" has been revised with the addition of data for a further seven timbers.

In addition to the above, 28 papers were published in the scientific and technical press (see Appendix II) and a revised edition was issued of the brochure "Timber Research" describing the activities of the Laboratory.

The publication of original work in *Bulletins* and *Special Reports* and as papers in scientific and technical journals ensures that the results of research are permanently recorded in the literature and are available to other scientists and engineers. It is realized, however, that publications of this kind have a limited circulation and often do not reach works managers, technicians, and many others concerned with the processing and utilization of timber or, if they do, the practical significance of the information they contain is not always fully appreciated. In order to meet this situation, the results of the Laboratory's research are sometimes re-published in a more popular form and in less technical language as articles in appropriate professional and trade journals. During the year efforts have been made to intensify and extend this practice with the object of bringing information more widely to the notice of those who are in a position to use it.

STAFF CHANGES

The Laboratory lost the services through retirement of Mr. P. Harris after 31 years. Trained in mechanical engineering, Mr. Harris was an acknowledged expert in the field of woodworking and he co-ordinated the work of the engineering sections. Mr. C. J. N. McCracken, Officer in Charge of the Publications and Records Section, also retired. He had served the Laboratory for 28 years, building up the valuable library services for which he was responsible, together with the editing and publishing of the Laboratory's reports.

Dr. E. J. Gibson, formerly of the Warren Spring Laboratory, was transferred, on promotion to the rank of Senior Principal Scientific Officer, as Head of Division A, Science. Mr. F. H. Armstrong, similarly promoted, became Head of Division B, Engineering. Mr. J. M. Baker was appointed as a Senior Scientific Officer in the Entomology Section.

PROGRAMME OF RESEARCH

DIVISION A (Science)

WOOD STRUCTURE

COLLECTION OF TIMBER SPECIMENS

During the year an exchange arrangement was made with the Smithsonian Institution, U.S. National Museum, Washington and a collection of some three hundred specimens, many of Central American origin, has been received. Under existing exchange arrangements collections have also been received from the Laboratório de Histologia e Tecnologia de Madeiras, Lisbon, from

the Forest Department, Tanganyika and from the Commonwealth Forestry Institute, Oxford, including over a hundred specimens collected by the Oxford University Expedition to Borneo 1955-6. The collection now contains over 27 000 specimens.

HOME-GROWN TIMBER INVESTIGATIONS

Timber improvement by selection and breeding. Progress has been made in the joint project with the Forestry Commission to examine the timber quality of "plus" trees, that is, trees of good growth characteristics selected as possible sources of seed for future plantings. Large diameter increment borings have been taken from several plus trees of Sitka spruce and, in order that allowance can be made for the effect of site on the timber quality when comparing the different plus trees, additional samples have been taken from five representative trees in the vicinity of each plus tree. Observations are being made on density and its variation within each sample, grain inclination, fibre dimensions and chemical composition.

Attention has been paid to improvements in methods of measuring anatomical features on these small timber samples, particularly to more efficient means of measuring and recording the lengths of fibres and of determining inclination of the grain. The beta-ray micro-scale method of density determination (which has been further refined, see page 13) is now in regular use for the study of density variation in individual growth rings.

There is some evidence that density, fibre length and grain inclination, are heritable and after assessments have been made on the plus tree borings, the existing progeny of these trees will be examined to determine the extent to which the timber characteristics can be passed on. In this way it should be possible to select those plus trees which offer the best prospects of producing future generations of trees superior in respect of timber quality as well as in vigour and habit of growth.

Lodgepole pine. The examination of the 28-year old trees from Blessington, near Dublin, was completed and confirmation obtained that this North American species produces a useful timber when grown under conditions similar to those in this country. The test material is believed to have been derived from two different provenances grown on neighbouring plots and the observations gave some indication of the importance of seed origin in determining timber quality, the timber from one provenance (probably the Olympic Peninsula) being distinctly superior to that from the other (probably Mount Rainier). Seed origin was also found to affect wood structure in thinnings from nine provenances obtained from a high elevation in North Wales. A further series of tests on trees of sixteen different provenances grown at Wykeham, Yorkshire, is in progress.

In general the home-grown timber is fairly uniform in texture, of moderate density and comparatively free of spiral grain. As far as fibre length is concerned this species appears to be rather similar to Sitka spruce of like age, and superior in this respect to Scots pine.

Pinus holfordiana. Although based on a single tree, studies of the timber of *Pinus holfordiana* were of considerable interest as the species shows promise as the source of a fine, even-textured wood, comparable to and even finer in texture than that of yellow pine. *P. holfordiana* shows a remarkably uniform fibre-wall thickness across the growth ring, with little, if any evidence of a distinctive band of thick-walled summer wood tracheids.

Turkey oak. Turkey oak is generally regarded as a less attractive timber than that of the European (white) oak. This view was confirmed in recent studies which showed that it possesses not only a heavier but somewhat darker wood than European oak. An interesting feature of the consignment under test was that, under forest conditions, the trees, from 106 to 126 years old, had maintained vigorous growth for only 40-50 years; thereafter the growth rate had declined and the sapwood, usually wide in Turkey oak, was narrow, $1\frac{1}{4}$ - $2\frac{1}{2}$ in., although representing 40-50 years growth.

CHEMISTRY

WOOD ANALYSIS

Nitrogenous components of wood. Wood contains a small percentage of nitrogen compounds. In most species the nitrogen content is not greater than about 0.1 per cent by weight but even this small amount is believed to be important in connection with biological processes of decomposition. It is therefore of interest to have information on the amount and distribution of the nitrogenous components of wood. In the course of an investigation on the variation in chemical composition of wood within the tree, reported in last year's annual report, pp. 35-38, it was shown that the nitrogen content of Sitka spruce wood is greatest in the outermost parts of the stem and falls towards the pith. The variation in nitrogen content in Douglas fir and European oak has now been examined in greater detail by separating the wood into individual growth rings and, in the case of Douglas fir, analysing the spring wood and summer wood of each growth ring separately. The results are summarized in the following table, in which the nitrogen contents are expressed as percentages of the dry weight of wood.

Table 1
Nitrogen content of European oak and Douglas fir

				European oak	Douglas fir	
					Summer wood	Spring wood
Bark	outer	..	..	0.285	0.536	
	intermediate	..	..	0.616	—	
	inner	..	..	0.736	0.687	
Sapwood	1st growth ring	..		0.283	0.109	0.144
	2nd growth ring	..		0.172	0.064	0.092
	3rd growth ring	..		0.206	0.058	0.092
	remainder (average)	..		0.113	0.059	0.097
Heartwood (average)		..	..	0.064	0.035	0.054
Centre of stem		..	..	0.117	0.054	

In agreement with the limited information available from other sources¹, the nitrogen content is highest in the inner bark and the outermost sapwood, that is, in the regions adjoining the cambium, and falls off sharply on both sides. In both species the sapwood has an appreciably higher nitrogen content than the heartwood and in Douglas fir the nitrogen content of the spring wood

is uniformly greater than that of the summer wood. If the higher density of the summer wood is taken into consideration and the nitrogen content is expressed per unit volume of wood, this latter difference is considerably reduced.

A preliminary examination of obeche has shown that this timber has an unusually high nitrogen content. This point is being examined further in relation to the varying susceptibility of this timber to attack by different wood-boring insects.

WOOD POLYSACCHARIDES

Polysaccharides of lodgepole pine. Much attention has been given in recent years to structural investigations on the polysaccharides of the wood of coniferous trees. The water-soluble polysaccharide of lodgepole pine (see last year's annual report, p. 39) contains galactose (7 parts) and arabinose (1 part) along with smaller amounts of xylose. It thus belongs to the group of arabinogalactans, and methylation and hydrolysis studies have shown that it has a structure basically similar to that of the arabinogalactans previously isolated from other *Pinus* species, e.g. *radiata* pine².

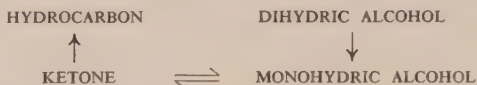
Attempts to fractionate the purified arabinogalactan by conventional dissolution and precipitation methods were unsuccessful, in spite of the fact that an examination of the material on the ultracentrifuge, carried out at the University of Edinburgh, revealed the presence of at least two components in approximately equal amounts. It was later found that the relative amounts of the two components may vary considerably in preparations from different sources, due possibly to seasonal variations in the composition of the wood.

Attempts are now being made to fractionate the arabinogalactan using the cetyltrimethylammonium hydroxide—boric acid method of Bouveng and Lindberg³.

WOOD EXTRACTIVES

Pyinkado. The syrupy material obtained by light petroleum extraction of the comminuted heartwood (see last year's annual report, p. 39) has been separated by column chromatography on alumina into seven pure components. Three of these have been completely identified, namely β -sitosterol, manoyl oxide and the previously unknown 2-ketomanoyl oxide.

The remaining four diterpenoid compounds, which are also new, are inter-related and consist of a hydrocarbon, a ketone, a monohydric alcohol and a dihydric alcohol. The following interconversions have been established



Tentative structures for these four compounds have been proposed on biogenetic grounds and by analogy with other diterpenoids of known structure; further work to confirm these structures is in progress.

Larch. An examination of the extractives of European larch and Japanese larch has been started in order to find whether their natural durability can be attributed to any specific component of the woods. The principal extractive having fungicidal properties is dihydroquercetin, which is known to be largely responsible for the durability of Douglas fir. A quantity of dihydroquercetin has been prepared from larch wood for examination of its fungicidal activity.

PHYSICS

DENSITY DETERMINATION

Work has continued on the method of measuring the variation of density across growth rings by means of beta particle absorption.

The equipment has been calibrated using sections of Douglas fir, Sitka spruce, horse-chestnut and "Knysna boxwood", specially selected and cut to cover a range in density and to be as uniform in texture as possible. These give a satisfactory straight line calibration, but there is some scatter of the points about the line caused by variation of density within the specimens.

In order to check the linearity of the calibration curve and also to provide a readily available routine reference standard, calibrations were carried out using a range of thicknesses of cellophane sheet, previously tested for uniformity. The line corresponded very closely with that for wood and has therefore been adopted as a routine standard.

Experiments have also been made on the effect of varying the width of the detector slit. As the width is decreased the resolution of a sharp density discontinuity is improved, but the reduction in count rate means that the actual density can be measured less accurately. Thus for a given feed speed of the specimen and time constant of the equipment, the selection of the slit width will depend on whether it is more important to resolve sharp density changes or to measure the density as accurately as possible.

Records of the density variation across the annual rings of four softwoods are reproduced in Plate 2 together with photomicrographs of the same sections. The traces for yew and Sitka spruce are similar in pattern although the yew has a higher average density. In European larch the variations in density between spring wood and summer wood are very large (0.2 to 0.9 gm/cm³), whereas in podo, a tropical timber, the density variation is almost negligible.

The beta particle equipment is intended mainly to determine the variation in density, from point to point, but the average density can also be obtained from the records if required. Other methods of density determination, for instance those involving liquid displacement or maximum moisture content, are still useful for determining average density. During the past year it was found necessary to determine the density of some experimental chips to assess the compression which the wood had undergone during the cutting process. The water displacement method could not be used because immersion in water would cause the wood to swell and would relieve the compression. By using toluene, a non-swelling liquid, in place of water, however it was found possible to determine the density of the compressed wood satisfactorily.

DIFFUSION OF WATER VAPOUR IN WOOD

The experiments on dynamic sorption of water by Corsican pine described in last year's annual report p. 40 indicated a pronounced maximum in the diffusion coefficient at about 15 per cent moisture content. Some experiments have now been made using a static method to determine the variation of diffusion coefficient with moisture content. The method depends on establishing successively higher relative humidity gradients across discs of wood and measuring the corresponding rate at which water vapour travels through the discs. Results for beech in the longitudinal, radial and tangential directions again suggest that the diffusion coefficient passes through a maximum with increase in moisture content. Static measurements are now in progress on discs cut from the Corsican pine specimens for comparison with the dynamic results.

ELASTICITY OF WOOD

The available equations for the deflection of plywood plates under distribution and concentrated load are in the form of infinite series. The equations have been examined and the accuracy obtainable by taking various numbers of terms in the series has been determined for three ply and five ply rectangular plates. A report is being prepared.

The propagation of vibrations in wood is of interest from the point of view of testing and possibly of treatment. The Basic Physics Division, National Physical Laboratory, is concerned with problems of wave propagation in various materials and a programme is available for use with their DEUCE machine which enables the wave propagation characteristics of materials to be calculated. Basic data for European oak, ash and European spruce have been supplied to the Division, and the corresponding wave characteristics evaluated⁴.

When determining the Young's modulus from the flexural vibration frequency of wooden beams, the results must be corrected for the shear deformation which accompanies bending. This correction is based on an approximate equation, and one of the factors in this equation (the shear deflection coefficient) is determined empirically.

An exact solution of the flexural vibration problem has recently been given for the particular case of a bar of circular cross section⁵. Calculations have been carried out here during the past year to compare the approximate and exact solutions and although the experiments with wooden beams were carried out on specimens of rectangular cross-section, it was found that the empirically derived value of the shear deflection coefficient agrees quite closely with that derived from the comparison between the exact and approximate solutions.

PULP AND PAPER

FACTORS AFFECTING REPRODUCIBILITY OF RESULTS

In last year's annual report pp. 39-40, it was noted that different results were obtained in pulp evaluation trials carried out at the Tropical Products Institute and at the Laboratory on samples of Sitka spruce. In more recent experiments, it has been found that, using the sulphate process, the degree of delignification reached in a given time increases with reduction in the amount of wood being pulped in a given digester, while the strength properties of the paper at a given lignin content were much poorer when small wood samples were used.

It would appear that the "free space" in the digester is an important variable, and that in any series of pulp evaluations carried out in small-scale experimental equipment, reliable comparative data can be obtained only if the factors of "free space" and degree of movement of the sample during cooking are carefully controlled in addition to conditions of temperature, time and chemical concentration.

SULPHITE COOKING OF SITKA SPRUCE

Some exploratory tests have been made on homegrown Sitka spruce using variants of the acid sulphite cooking process. Yields of up to 65 per cent of light-coloured, strong pulps have been obtained without resort to mechanical defibration by means of sodium based liquors in the pH range of 5.5 to 6.0. Indications are that cooks of this type may prove more informative than those

carried out using the lower-yield alkaline sulphate process in demonstrating differences in the pulping properties of wood from different sources.

LODGEPOLE PINE

The investigation of the pulping properties of lodgepole pine from different provenances has been extended to include a further 15 samples. The sampling procedure, cooking and testing conditions adopted for the original series of nine provenances, described in the previous report, have been reproduced in the current work so as to preserve the same basis of comparison throughout.

EFFECT OF FIBRE FORM ON PULP PROPERTIES

Work has been started on a programme to investigate the relation between the morphological, physical and chemical properties of coniferous wood "fibres" and the quality of pulp produced from them. Sitka spruce is being used in the first instance. In order to obtain timber samples containing the maximum variation in "fibre" properties it was decided to utilize the inherent variation between annual rings in a single tree. Tracheid length, diameter and wall thickness are being measured microscopically, and the variation in the rate of growth, density and percentage of summer wood of the timber are also being recorded. Chemical properties under investigation are hemicellulose and pentosan contents and the viscosity of the alpha cellulose.

Wood chips are prepared by hand and cooked by a standardized sulphate process to yield pulps of uniform lignin content. Pulp quality is determined by the physical testing of handsheets.

WOOD PRESERVATION

PRESERVATIVE TREATMENT OF HOME-GROWN POLES

A number of home-grown softwoods are accepted by the current *British Standard* 1990:1953⁶, as suitable for transmission poles. Most of them however are rather difficult to treat satisfactorily compared with imported redwood, which is normally used for poles in this country. The home-grown species, that is Scots pine, treats equally well but contains a considerably greater proportion of sapwood and as a result needs rather longer to season and a somewhat higher retention of creosote to meet the penetration requirements. An investigation has been undertaken to see what improvements can be made in the preservative treatment of these various species of home-grown poles. Some exploratory experiments have been carried out on Scots pine. The initial object was to examine the practicability of avoiding the long seasoning period by drying and creosoting the poles in one continuous operation in the creosoting plant by the Boulton process. The initial results indicate that the drying part of the operation is quite satisfactory. At present one disadvantage of the process is that, with the normal method of operation, the absorption of creosote during the drying period is rather high and, as a result, the final net retention is considerably higher than the normal specified figure.

THE PRESERVATIVE TREATMENT OF HOME-GROWN TIMBERS BY DIFFUSION

An increasing quantity of sawn softwood, mainly Sitka spruce and Scots pine, is now being produced in this country from the plantations of the Forestry Commission, and it is probable that, as time goes on this material will be used to an increasing extent by the building industry. Preservation of

these timbers could be provided by the same methods of treatment as are at present used for imported softwoods. But since the home-grown material will be available immediately after conversion, while it is still green, it will also be possible to treat it by a diffusion process. This would involve treating the timber with a water-borne preservative before seasoning and it has the advantage that complete penetration can be obtained even with timbers which are resistant to impregnation, such as Sitka spruce. The practicability of treating home-grown timbers with various water-borne preservatives by this method is being investigated as part of the research programme with the Forestry Commission. Some exploratory experiments have been carried out with Sitka spruce to find out how long the common building sizes, i.e. 1 inch, 2 inch and 3 inch, would have to be close-stacked for an adequate loading of preservative to diffuse to the centre. For this particular work a boron preservative was used. The timber was dipped in a 20-30 per cent solution according to thickness and the distribution of the preservative through the timber was measured after different times of diffusion and is shown in Fig. 2. A report on this work has been prepared⁷.

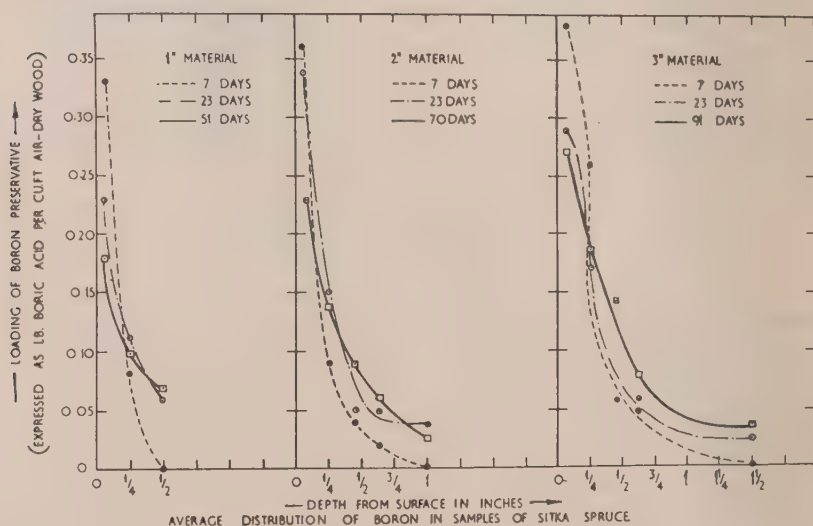


Fig. 2. Average distribution of boron in samples of Sitka spruce

METHODS OF ESTIMATING PRESERVATIVES IN WOOD

In the work described above there was some difficulty in estimating satisfactorily the distribution of the boron preservative through the wood. The usual method of estimating boron is not very well suited for observing the concentration gradients set up in the wood during the process of diffusion and a search has been made for a method more suitable for this particular work. The main disadvantage of chemical methods is that the boron has first to be separated from the wood and this makes the work slow when a considerable number of estimations have to be made. In general some physical method would be more suitable. A joint investigation with the National Institute for Research in Nuclear Science was started to examine the possibility of using the high absorption of thermal neutrons by boron as a basis for its estimation.

This work has shown that the boron content of treated wood sawdust can be estimated very accurately over a wide range of loadings by measuring the neutron absorption when a sample is placed in an experimental reactor. Unfortunately this method is too costly for routine work and the possibility of using a small neutron source and a bench apparatus instead of a reactor was investigated. This proved to be a lengthier and considerably less accurate procedure and in its present form it is not likely to be sensitive enough for the lower end of the loading range which it is desired to measure in this diffusion work. A report has been published⁸ on the work done to date, and ways of improving the sensitivity of the method are being examined.

THE EFFECT OF SIZE ON THE LIFE OF TIMBER IN CONTACT WITH THE GROUND

Field service tests to assess the natural durability of different species of timber have been in progress at the Laboratory for many years. The test consists of inserting standard size specimens in the ground at sites in different

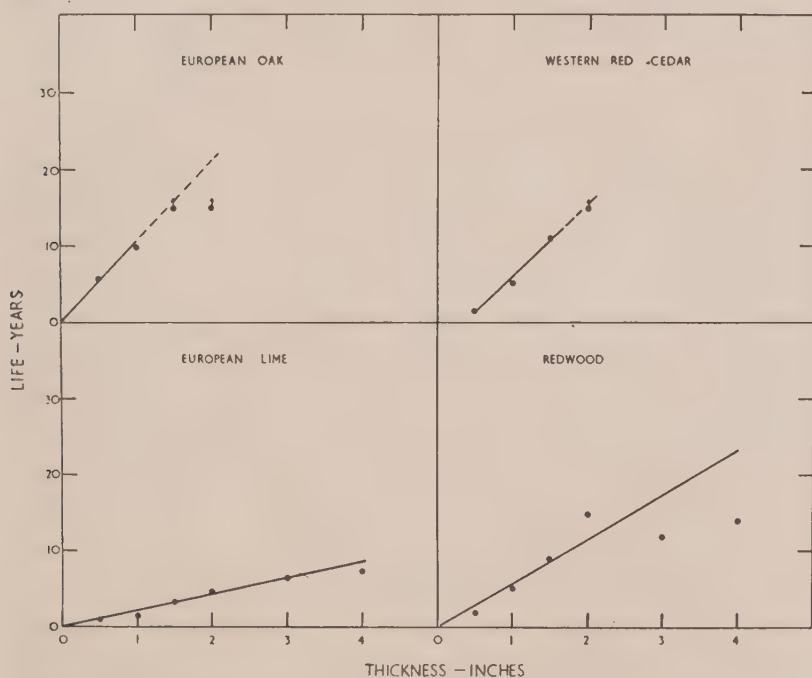


Fig. 3. Effect of thickness on the life of various timbers in the ground

parts of the country and recording the time taken for them to decay. The average life of the specimens of each timber is used as a measure of its relative durability and in a report published some time ago⁹ results were given for about 130 different species. The results of course also provide data on the actual life of the timber in the size used, i.e. 2 inch $\times$ 2 inch, when in direct contact with the ground. Such information is very useful for estimating the useful life of fencing, for example. The value of these tests would be

greatly increased if it were known how much extra life to allow when the size is increased to the various larger dimensions generally used in practice. To obtain some guidance on this further tests were started about ten years ago to try to establish how life varies with size. The tests are not yet complete but the results obtained so far have recently been reported.¹⁰ At present the indications are that the life of timber increases in direct proportion to its thickness, whether it is hardwood or softwood, perishable or durable (see Fig. 3). This knowledge enables the life of any size of material to be estimated from our existing durability data and will add greatly to its usefulness. It has helped to define much more precisely than was possible hitherto the durability of home-grown European oak, about which there has been a good deal of misconception because of the failure to allow for the fact that this species of timber is now generally used in smaller thickness than in the past, when its reputation for very high durability was established.

TREATMENT OF HOME-GROWN OAK FENCING

In the construction of home-grown European oak fencing it is the general practice to use freshly converted timber. Because of cost most of the timber used for this work is of relatively low grade and if it were allowed to dry out before being used a high proportion would often become distorted and difficult to assemble. The use of unseasoned timber avoids this difficulty but it is a disadvantage if preservative treatment is called for since standard practice requires the timber to be air dry before pressure or open tank impregnation with a preservative. In co-operation with the Forestry Commission some tests have been undertaken to assess the value of treating the green timber by diffusion with boron followed by a hot and cold treatment with creosote with the object of preventing the leaching of the water-borne preservative. One of the methods being used to assess this treatment is a laboratory leaching test on small samples. The results show that, to begin with, the creosote does very much reduce the rate of leaching of the boron, but the effect is only short-lived and by the end of a few months there is not very much difference in the amount lost from samples treated with boron and creosote and the controls treated with boron alone. At the same time other substances besides creosote are being tried to investigate more generally the possibility of preventing leaching of water-soluble preservatives. So far dipping in bitumen appears to be considerably more effective than a creosote treatment but it is too early yet to say whether it is likely to be of practical value.

PERMEABILITY OF WOOD

The immediate object of this work is to obtain a more fundamental understanding of the way in which preservatives and other fluids move through wood, and of how this is affected by the structure of the wood and the properties of the permeating fluid. From this it is hoped to learn whether there is any possibility of improving the permeability of refractory timbers, and, if so, how this is most likely to be done. One of the primary requirements in this work is to establish a method of measuring the permeability constants of wood along the three cardinal directions of the grain. Although preservation practice is concerned almost entirely with liquid flow, it is generally inconvenient, and often impracticable, to use a liquid for measuring the intrinsic permeability of wood, and in these investigations a permanent, inert gas, such as nitrogen, has been found to be much more satisfactory. In

recent work the mechanism of flow of gases through softwoods has been studied and it has been established that, except at low absolute pressures, it is viscous (Poiseuille) flow with slip. The viscous component of this flow is dependent only on viscosity and not on the state of the fluid and can be used therefore to derive a permeability constant which is applicable to the flow of any inert liquid through the wood.

Studies of the mechanism of flow of gases are being used also to determine the size of those openings in the structure of wood which control flow.

MYCOLOGY

CULTURE COLLECTION

The culture collection has been maintained in good condition and thirteen new cultures have been added. The catalogue of the collection has been revised and one hundred and eighteen cultures have been supplied upon request.

Institutions in this country and overseas have made requests for assistance in the identification of cultures. In particular assistance with the identification of a series of cultures isolated from standing softwood trees in Scotland has been given to the Forestry Commission Forest Research Station.

NATURAL DURABILITY TESTS

Comparative tests of the natural durability of home-grown European and Japanese larch are being carried out on timber from trees grown in different localities. It was hoped that the tests could be carried out on sawdust samples as these could be taken with greater ease than solid wood samples from selected points within the heartwood. However it was found that differences in decay resistance which were detectable when standard solid test blocks were used could not be discerned in matched samples of sawdust. It was concluded that the decay resistance of larch is related to the physical features of the wood as well as to chemicals toxic to fungi which are present in the wood and the main test is being carried out on standard test blocks of solid wood.

Tests of plantation-grown teak trees thirty-nine years old from Nigeria have given indications that the durability of teak heartwood from this locality, even from relatively young trees, may be as great as that of teak from Burma.

WOOD PRESERVATIVES

As it is considered to be a useful service to the wood preserving industry, laboratory testing of the toxicity of proprietary wood preservatives upon request by the methods laid down in British Standard Specification 838: 1961¹¹ has been resumed on a limited scale.

DRY ROT

The possible use of radio frequencies of 2450 megacycles for the sterilisation of brick walls infected with *Merulius lacrymans* has been investigated in collaboration with the Building Research Station. It has been shown experimentally using a power output of 2kW that the fungus can be killed at depths of 4.9 inches within the wall by a few minutes of treatment but the results indicate that death is caused by overall heating of the brickwork. In a moist wall there is no evidence that any preferential heating of the fungus occurs to bring about its death before the surrounding brickwork reaches a temperature of 40°C, the known death temperature of the organism. Experiments

have been confined to the treatment of small areas of brickwork (see Plate 3) and further development work will be required before the method can be used in practice.

Following the floods in south west England and South Wales in the early part of the year leaflets were prepared in conjunction with the Building Research Station telling householders and builders of the risks of decay developing in woodwork of flooded buildings and the measures that should be taken to reduce those risks.

SAP STAIN INVESTIGATIONS

Further trials of materials for preventing the entry of staining fungi into the cut ends of softwood logs have been carried out by the billet method (see last year's annual report, p. 29). Previous tests have shown the efficacy of creosote in controlling the entry of most blue stain fungi. However, *Hor-modendron resinae*, being creosote tolerant, was able to colonise creosote-impregnated wood, giving slight blue stain. The incorporation of 2 and 5 per cent pentachlorophenol* into the creosote resulted in a drastic reduction in the fungi colonising the cut ends of the billets after three months of test. With 5 per cent pentachlorophenol, the cut ends of the billets were quite clean after three months. Since agar plate tests had shown griseofulvin to be fungitoxic to various blue stain fungi, this compound was tested in a three-month billet trial at concentrations of 100 and 1000 parts per million. At 100 parts per million the amount of blue staining was reduced by a quarter and at 1000 parts per million was almost halved. Thus although partially effective this compound is not likely to afford economical control of blue stain fungi. Further billet trials with other materials are being carried out.

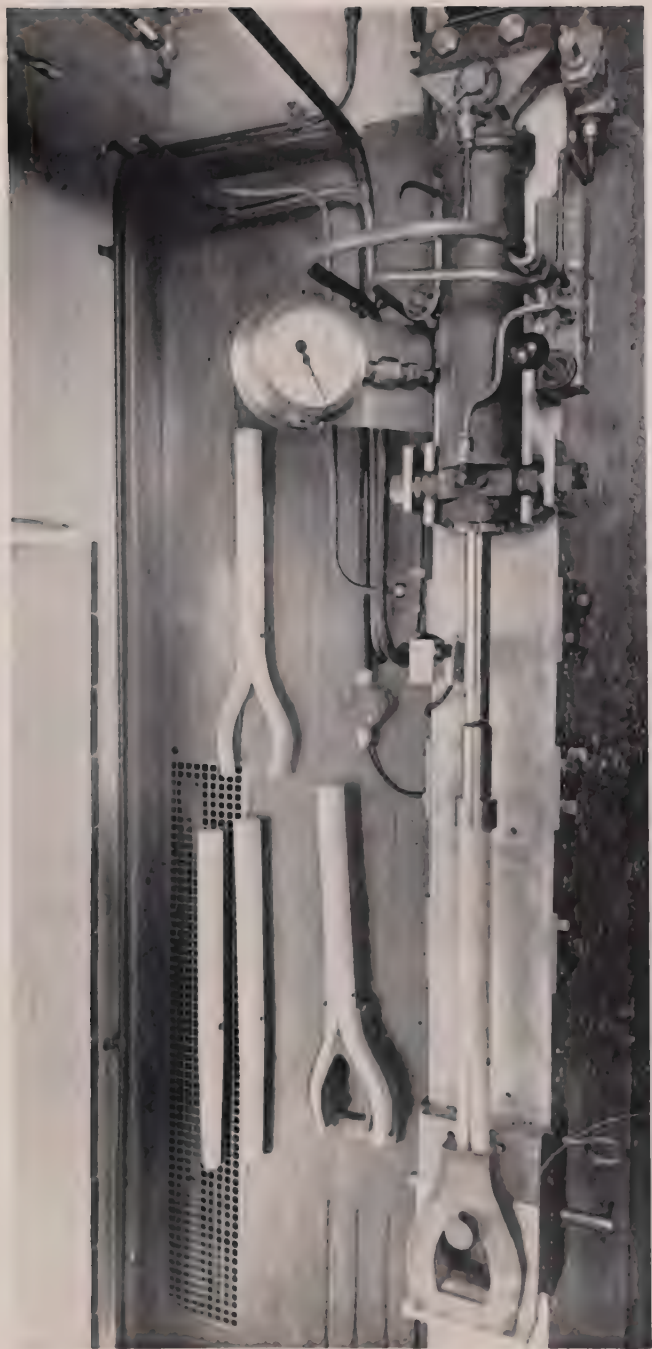
Laboratory determination of the identity of the fungi which cause sap-stain in naturally or experimentally infected material is often made difficult by the presence of the rapid growing common timber mould, *Trichoderma viride*, and a growth medium which would selectively discourage growth of this fungus would be of great value. Following reports¹² that 4 parts per million of duramycin completely inhibited the growth of *T. viride* and that very low concentrations of pentachloronitrophenol caused partial inhibition, both chemicals were tested in agar, but neither proved to be suitable for the selective separation of the blue stain fungi from *T. viride*.

During the year eight chemicals have been tested to determine their efficacy as sap stain preventives when applied to sawn timber.

FUNGAL PHYSIOLOGY

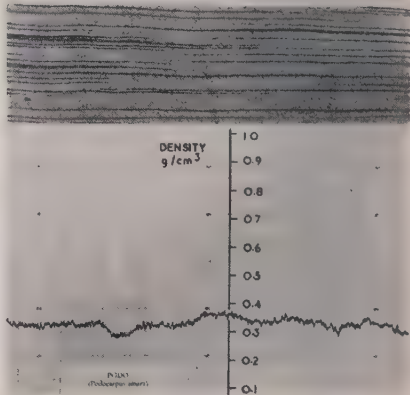
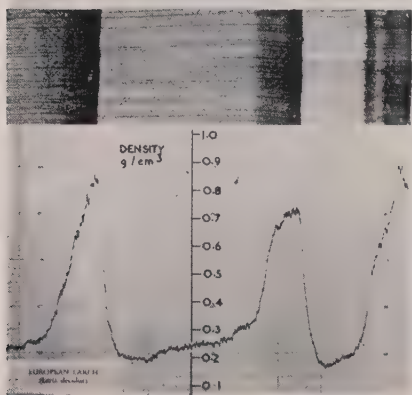
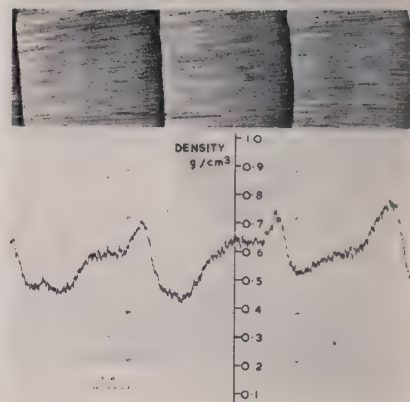
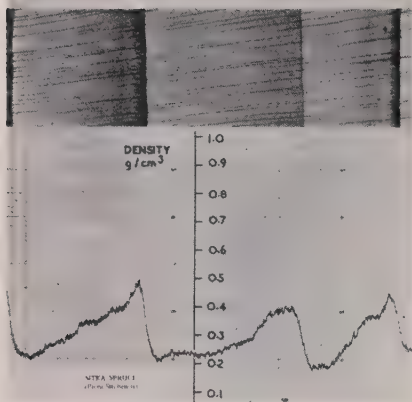
Respiration studies. Several experiments have now established that at low concentrations sodium fluoride stimulates the decay of wood by *Coniophora cerebella*. 0.02 per cent is the optimum concentration at which the rate of decay is almost doubled (see Forest Products Research 1956, p. 34). Attempts have been made to relate this increase of decay to an acceleration in the rate of respiration of the fungus. The liberated carbon dioxide was absorbed in barium hydroxide and estimated by titration with standardized hydrochloric acid. The results obtained to date, using this technique, have proved inconclusive and conductometric methods for the continuous estimation of respired carbon dioxide are being considered.

* strictly pentachlorophenoxide.



The experimental machine used for compressing and bending the split Y-D type spade handle

PLATE I



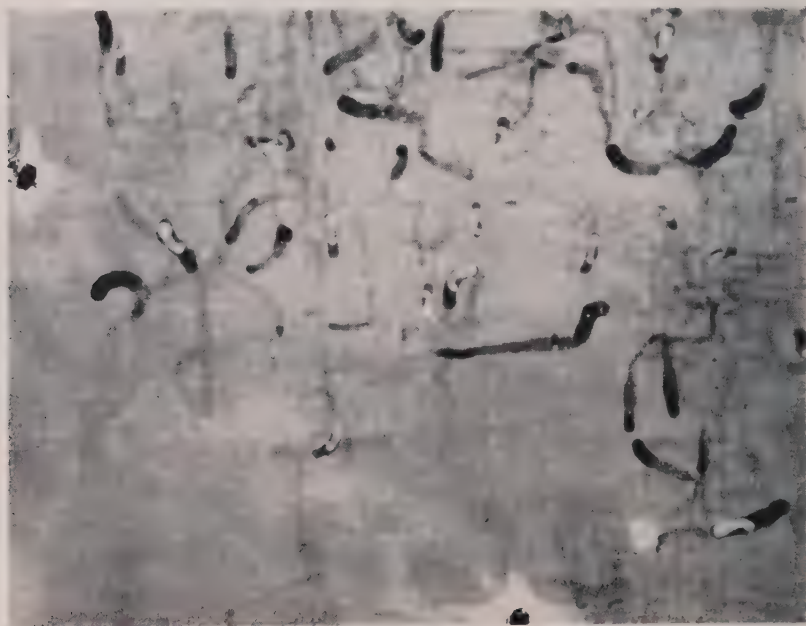
Records of density variation across individual growth rings obtained with the beta-ray equipment together with photomicrographs of the corresponding sections



Recording temperatures in culture tubes of *Merilius lacrymans* after irradiation of an experimental wall



(a) Surface of birch plywood showing exit holes caused by *Anobium* beetle (Natural size)



(b) Radiograph of same portion showing active larvae. The dark shadows are tunnels.



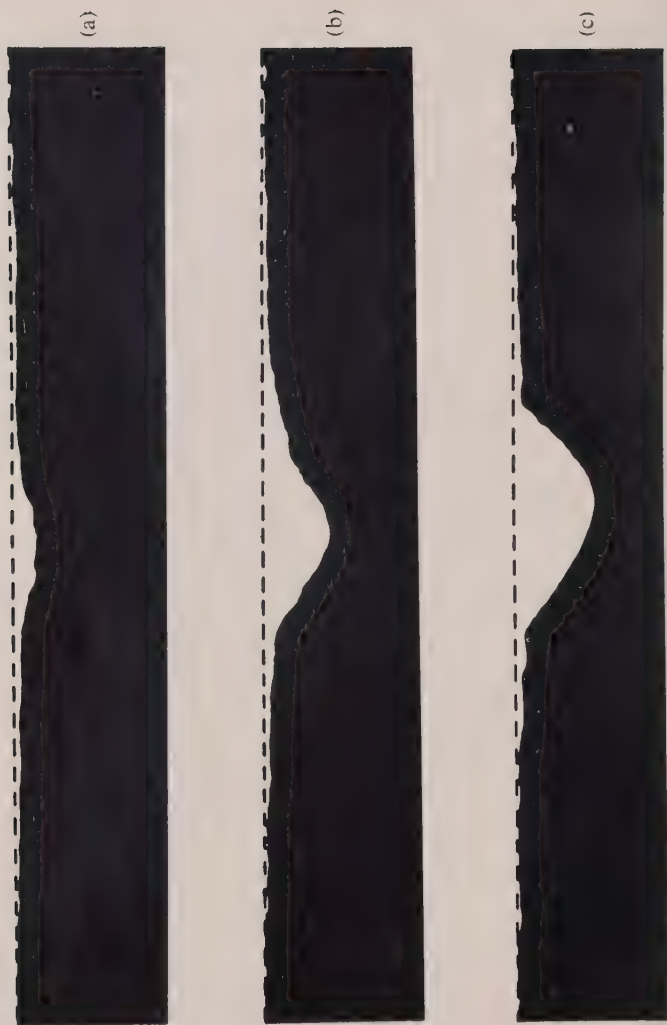
Small-scale plant for chipboard manufacturing. From left to right: spray-gun, pattern, tumbler, split box for mat forming, pendulum for examining.



A structural design to demonstrate the use of home-grown softwoods in straight and curved laminated construction.



Appearance of textured concrete resulting from the use of home-grown
Douglas fir shuttering



Pattern of cutter wear after machining along a glue-line:
(a) moderate glue, (b) abrasive glue, (c) very abrasive glue. Mag. $\times 130$.

General gaseous relationships during decay. Experimental results suggested that the accumulation of respired carbon dioxide may cause a reduction in the rate of decay of wood by fungi (see last year's annual report, p. 27).

Using European spruce sawdust as the medium for growth of *C. cerebella* it was shown that the amount of decay was increased when the respired carbon dioxide was absorbed by "carbisorb" (indicator soda-lime). This confirms the hypothesis that accumulation of carbon dioxide hinders decay in culture bottles incubated in an upright position. Improved techniques are being considered to investigate more critically the effect of carbon dioxide tension upon the rate of fungal decay.

ENTOMOLOGY

ECONOMIC PROBLEMS

It is the opinion of many architects, surveyors, pest control firms and others engaged in the care and maintenance of buildings that damage by the common furniture beetle (*Anobium punctatum*) has increased. The annual cost to the nation of the consequent treatments and repairs is considered substantial. Such estimates are largely conjectural, and there is a need to ascertain the extent of attack by the various wood-destroying insects and fungi, and the cost of consequent repairs. To obtain this information the possibility of conducting a pilot survey is being investigated.

BIOLOGY, HABITS AND NUTRITION

Studies have been concentrated on the more prevalent wood-boring insects.

Common Furniture Beetle (Anobium punctatum). A decrease in nutritional suitability across the width of trees of home-grown Sitka spruce from the bark towards the centre has been demonstrated by insertion of larvae into sample blocks and subsequent studies on their rate of development. Similar results were previously obtained for Corsican and Scots pine (see Forest Products Research 1954, p. 33, and 1956, p. 38). Further studies on the effect of soft rot decay on beech showed that larvae gained weight more rapidly in the more heavily decayed material.

House Longhorn Beetle (Hylotrupes bajalus). Previous experimental work revealed that warm weather was especially favourable to emergence of adults and hatching of eggs (see Forest Products Research 1955, p. 36). Data provided by the Meteorological Office on the mean isotherms show that these are highest during the breeding months of this insect (mainly July and August). The highest mean temperatures occur in an area to the south-west of London closely corresponding to the main centres of infestation of this species (see Fig. 4). These observations taken together may account for the limited distribution of this insect in England. Since 1925 the temperature of the hottest month of each year has tended to be well above the average of the last century in south-east England and this could have influenced the increase in infestation which has been detected, chiefly in the Surrey area, since World War II. Further experiments are being carried out on the relationships of temperature to the hatching of eggs, and maximum and minimum temperatures are being recorded in roof spaces in a *Hylotrupes*-infested area for comparison with outdoor readings to seek correlation with the Meteorological Office records.



DAILY MAXIMUM TEMPERATURE FOR
AUGUST, AVERAGE MEANS (°F) FOR 1901-30



⊗ ISOLATED ATTACKS
▨ AREA OF MAIN INFESTATION
OCCURRENCE OF HYLOTRUPES ATTACKS IN
BUILDINGS.

Fig. 4. Occurrence of *Hylotrupes bajulus* in relation to daily maximum temperatures in August

Results of experiments (see last year's annual report, p. 32) on the effect of different temperatures and humidities on the rate of growth of larvae are given in the Table 2. Larvae introduced into freshly felled Scots pine sapwood were conditioned at 25°C and 75 per cent r.h. for 6 months before being subjected to the experimental conditions for 12 months.

Table 2
Effect of different temperatures and humidities on growth of Hylotrupes larvae

Experimental conditions	Mean larval weight after 12 months in these conditions (mg) (Numbers of larvae weighed in parenthesis)
Incubator, 28° C, 85 per cent r.h.	373.1 (23)
Wet tropical: daily variations from 25° C to 29° C and from 75 to 85 per cent r.h.	356.2 (20)
Roof space containing pipes in a central heating circuit.	223.6 (15)
Dry tropical: daily variations from 27° C to 40° C and from 20 to 42 per cent r.h.	134.0 (17)
Fluctuating daily from 28° C at noon to 15° C; humidity not controlled.	61.16 (6)

The slow rate of development under the last conditions given in the table is somewhat surprising since these were designed to reproduce the natural conditions of warmer climates where the life-cycle is known to be shorter than in Europe.

Since *Hylotrupes* is to some extent a cell content feeder, it appeared probable that the presence of blue stain in softwoods might decrease their nutritional suitability. This has been confirmed experimentally by the insertion of newly hatched larvae into matched stained and unstained billets of Scots pine. After 12 months at controlled conditions of 25°C and 75 per cent r.h. the average larval weight in blue stained billets was significantly less than in the unstained controls.

The Death-watch Beetle (Xestobium rufovillosum). In view of the serious damage caused to many of our ancient buildings by the death-watch beetle it is desirable to test the toxicity of wood preservatives to this species. It is, however, difficult to obtain supplies of beetles and studies are being continued on the possibility of culturing this insect in decayed European oak sapwood. Adults have been reared from eggs laid 16 to 17 months previously and this work has yielded useful biological data.

PREVENTION AND CONTROL OF INFESTATIONS

Investigations have been continued on prevention of ambrosia beetle attack on softwood logs in Scotland and on methyl bromide fumigation and gamma irradiation for control of other types of infestations. A detailed account of the techniques employed at this Laboratory when *Anobium* or *Hylotrupes* is used as the test insect has been published.¹³

Ambrosia Beetles. Further experiments have been carried out in conjunction with Forestry Commission entomologists, on methods of preventing attack by *Trypodendron lineatum* on newly felled timber in Argyllshire forests. Much more widespread attack occurred in logs piled in stacks of varying sizes by the roadside than was found in previous years in logs left at stump. Attack was concentrated on the outside logs of the untreated control stacks and decreased towards the centre. Final examinations made in July showed that spraying other stacks with 0.75 per cent gamma benzenehexachloride before attack started in April reduced attack very significantly in December felled timber and complete protection had been achieved by spraying the March felled Sitka spruce.

A further experiment was carried out with 800 stems felled in May and June and left untreated at stump with the object of ascertaining how long freshly felled timber could remain in the forest during the peak period of beetle activity, before it became attacked. None of these logs were attacked, indicating that felling operations need not be suspended during this period (provided logs are left at stump) as had been the practice in one forest.

Methyl bromide fumigation. Investigations to determine the toxicity of this gas to *Hylotrupes* and *Xestobium* are in progress.

The quarantine regulations in Australia seek to prevent the introduction of Siricid wood-wasps into that country. These insects are sometimes found in softwood packing cases and hence these regulations are an important consideration for British exporters. In order to provide larvae for studies on the susceptibility of a common wood-wasp to methyl bromide, logs of European spruce have been exposed for egg laying to *Urocerus gigas*.

Besides these laboratory studies, further data have been obtained on the results of previous fumigation treatments carried out in H.M.S. Victory. A slight increase occurred in the numbers of death-watch beetles emerging—possibly resulting from the progeny of beetles which escaped the last fumigation treatment 5 years ago, but the numbers of beetles remain small.

Gamma radiation. Further studies made on sample blocks of decayed European oak sapwood into which death-watch larvae were inserted and which were irradiated in 1958, have confirmed that a dosage of 4000 roentgens (r) is insufficient to prevent emergence of beetles but treatments at 6000 and 8000 r were successful. Irradiation of naturally infested material at 10 000 r had shown that adults emerging during the spring following treatment were sterile and larvae either failed to reach the adult stage or developed into sterile adults (see last year's annual report, p. 38). This year, however, a few adults emerging from such material irradiated at 12 000 r in 1960, laid viable eggs. The explanation of this anomalous result probably lies in the difficulty of obtaining a uniform dosage in the irregularly shaped samples of naturally infested wood available, which could result in some larvae receiving a comparatively low dose. Further material has been prepared to repeat this experiment.

The possibility of using lower dosages of gamma radiation (4000 r) to endeavour to affect subsequent generations, has been investigated by irradiating larvae of the powder-post beetle, *Lyctus brunneus*. Studies continued into the F3 generation showed that the population level recovered without any apparent long-term adverse effects.

TECHNIQUES

An X-ray equipment has been installed for the examination of naturally and experimentally infested material. Since earlier experiments¹⁴ developments in the design of such equipment now permit its effective use not only to save much time in non-destructive examination of attacked wood, but also to undertake some biological investigations not previously possible.¹⁵ By X-ray photography it is possible, for example, (a) to ascertain which naturally infested samples are most suitable to cut up for the provision of live larvae for insertion into test blocks (see Plate 4), (b) to study the progress of these larvae in such blocks and (c) to assess the results of treatments given to the blocks without having to section them. Data previously obtained on the susceptibility of wood-boring insects to gamma rays have proved of great value when deciding to employ X-ray techniques.

COLLECTIONS

Over a period of more than 30 years, a reference collection of samples of damage caused by a large number of species of wood-boring insects in a wide variety of timber species and wood products has been accumulated. This collection has now been catalogued and is thus available for study by those concerned with these problems.

DIVISION B (Engineering)

SEASONING

KILNS AND KILN SEASONING

The large kilns were used for seasoning consignments of niangon, abura, teak, afrormosia, oak and beech. Although the niangon and beech were dried in 3 inch thickness very good results were obtained. In addition to the hardwoods mentioned, a parcel of home-grown cedar of Lebanon was kiln dried.

In the smaller kilns, loads of Indian rosewood, yellow seraya, hornbeam, hickory, greenheart and Nigerian grown teak were seasoned. Tests were also carried out to determine faster drying schedules for purpleheart and utile. Two kiln runs were completed to obtain information on the most satisfactory piling methods and kiln treatment for "Maracaibo boxwood" slats for the manufacture of rules.

HOME-GROWN TIMBER INVESTIGATIONS

Kiln seasoning of boards from young trees of home-grown American red oak showed that longitudinal distortion tended to be a troublesome defect. Other species tested in co-operation with the Forestry Commission were European and Japanese larch from three different sites and lodgepole pine representing fifteen different provenances.

ACCELERATED AIR-DRYING OF PITPROPS

In order to obtain data on the possible use of mobile air heaters to accelerate the air-drying of pitprops during the winter months, a series of

tests was carried out in a long miniature kiln adapted so that typical drying conditions could be simulated. Twenty foot long loads of $4\frac{1}{2}$ inch diameter pitprops were dried without excessive degrade down to 55 per cent of their original weight in only sixteen days. An attempt was made to estimate the cost of such drying in the field and a report¹⁶ on the findings has been prepared.

COLOUR CHANGES DURING THE DRYING OF BEECH

As mentioned in last year's report (p. 9) it is frequently desirable that seasoned beech should be of a uniform light colour, and further tests have been carried out with the aim of determining the best way of preserving the natural colour during the seasoning process. It has been demonstrated that beech which is allowed to dry slowly under warm humid air conditions (25°C and 90 per cent r.h.) is liable to become affected by discoloration in the form of irregular dark grey patches and that this discoloration is not attributable to fungal attack. It has also been shown that kiln drying at the temperatures and humidities normally recommended for green beech causes a slight general darkening in the colour of the wood, and that this effect can be noticeably reduced by employing lower temperatures and lower humidities throughout the kiln treatment. When this is done, however, some end-splitting and surface checking on flat-sawn surfaces may occur. Pre-treatment of the green timber by dipping it in various chemical solutions, including a buffered sodium azide solution reported to have been used successfully in America for the control of brown stain in sugar pine¹⁷, has been tried but has proved to be ineffective.

DISTORTION EXPERIMENTS

Earlier experiments have shown that the effect of imposing mechanical restraint on timber samples during drying is to cause a reduction in their ultimate distortion. This effect increases with the temperature at which the drying is conducted, and curvature across the grain (cupping) is reduced to a greater extent than longitudinal distortion.

An additional series of tests¹⁸ has been made to examine the behaviour of beech samples, initially green, which were over-dried to varying extents and then re-wetted to the desired final moisture content, before the restraint was removed. It was found that the effect of the combined over-drying and re-wetting was a further reduction in the ultimate distortion, and there was a progressive improvement in the final shape of the samples as the amount of over-drying was increased.

ANTI-SHRINK TREATMENT

A pilot test on the efficacy of polyethylene glycol 1000 (a soluble wax-like semi-solid) as an anti-shrink material gave promising results and further investigations are being carried out. A $1\frac{1}{2}$ inch disc of Scots pine required for exhibition purposes was impregnated with this substance and successfully dried without splitting.

WOOD BENDING

An extensive series of tests designed to determine the effect of various longitudinal compression treatments on the limiting bending radius of beech has been completed¹⁹. It was found that the limiting radius for bending in the cold state, material that had previously been steamed and compressed decreased approximately with the increase in residual strain.

Of practical importance was the finding that wood that has been compressed and immediately released from stress retains some residual strain and can be bent to a relatively small radius when cold. Pre-compression was the basic principle underlying the method recently developed at the Laboratory for bending the split Y-D type spade handle, which is now covered by a provisional patent. An experimental handle-compressing and bending machine has been designed and constructed at the Laboratory (see Plate 1).

The bending properties of a number of species in solid and laminated form have been investigated and among these was teak grown in Nigeria. A large scale investigation has been started to determine the effects of impregnation with some water soluble preservatives on the bending properties of beech.

COMPOSITE WOOD

STUDIES OF GLUES AND GLUING

Durability of adhesives for plywood. A progress report²⁰ has been prepared on Series V. Begun in 1954, this project has been progressively widened to anticipate the needs of industry for durability data, and this year, tests on the influence of filler properties upon phenolic resins have been added. A surprising result of the recent examination has been the extensive failure at three years of urea glues when subjected to a cyclical test in the Dry and Wet Rooms of the Tropical House, though they have remained sound under continuous exposure in the Dry Room. African mahogany and beech plywood, bonded with phenolic glue set at 115°C, developed widespread chemical discoloration when exposed to Wet Room conditions but staining did not occur in Dry Room storage.

Beam test-unit for assembly glues. In last year's annual report, p. 18, an account of a new test-unit was given which provided four ways of assessing bond quality. In the current year, work has continued to establish its characteristics and to develop a standard statistical method of analysing results. The test-unit is now being used to investigate difficulties in the gluing of Scots pine, and it will be employed to examine the effects of durability on temperatures induced by solar radiation. The intensity, duration and frequency of radiation has been studied and conditions are reproduced by a long bank of infra-red lamps controlled to a prescribed cycle.

Factors in gluing. The study of the formation of glue bonds has been extended²¹ to include seven brands and three types of resin adhesives. Table 3 gives the preferred setting conditions for optimum bond quality within a temperature range of 25–95°C and pressures of between 25–200 lb/sq. in. on plywood panels 6 inches square.

Table 3
Recommended setting conditions for optimum bond quality

Glue type	Temperature	Pressure
Urea	Low	High
Resorcinol-phenol	High	Low
Resorcinol / ..	Low	Low

RADIO FREQUENCY HEATING

Ageing of glued joints set by radio frequency. Ageing tests extending over ten years²² on several types and brands of resin glue have shown that when initially set by radio frequency in 60 seconds, none decline in joint strength faster than when made at room temperature. Under a 10 second cure some glues had a lower initial failing load. Their rate of strength loss however was slow so that the joint strength will probably coincide with the strength of joints of higher initial failing load which are declining at a slightly faster rate. It is now known²³ that the performance of those glues that gave a low initial failing load can be improved by adjusting their viscosity-temperature characteristics, so it appears that setting by radio frequency methods is without deleterious effects.

Electrical constants of wood-glue composites. When radio frequency heating is used to cure an adhesive in a composite, the power is divided between the wood and the glue and only that absorbed by the latter serves a useful purpose. An equation for this division between wood and glue has been established for two basic heating arrangements in terms of the loss tangent and the permittivity of the composite and of the wood alone, and a technique has been devised for measuring the constants of radio frequencies²⁴.

Measurement of radio-frequency power. In last year's annual report, p. 20, the preliminary design of an instrument was described for measuring the radio frequency power delivered by a generator to a load. This instrument has now been fully developed and the provisional patent applications completed. Tests with a water calorimeter indicate that the signal from the instrument is a true measure of the absorbed power.

BARK FORM AND VENEER FIGURE IN BIRCH

Practical work to relate bark form with veneer figure in home-grown birch has been completed. The report²⁵ shows that while rough bark is usually indicative of disturbed grain in the veneer, the decorative value of the latter is not necessarily high. The much-prized "flamy" figure has been found under several definable forms of bark, but not with the regularity that would help in tree selection. The uses of other external features for this purpose are being investigated by the Laboratory and the Forestry Commission.

CHIPBOARD MANUFACTURE AND PROPERTIES

Early in 1960, the British chipboard makers asked the Laboratory to undertake some fundamental research on this material. A first appraisal of the problems involved was made after visiting the firms concerned, studying world-wide literature on the subject, and consulting with French and German research establishments. A short-term experimental project was begun in April 1961 comprising:—

- Building of a small scale plant for manufacturing boards (see Plate 5).
- Development of a technique for making and testing chipboards.
- Basic work on the moisture relation of chips.
- Microscopic studies of chip form and the glue bond between chips.

Upon the results of this work, the Wood Chipboard and Particle Board Group of the British Plastics Federation agreed to sponsor continuation and extension of the work for a further period of two years.

TIMBER MECHANICS

QUALITY AND PROPERTIES OF HOME-GROWN TIMBERS

The investigation into the strength and specific gravity of Sitka spruce grown in Great Britain described in last year's annual report, p. 10 has been completed and a report published²⁶. The results described previously were based on green test specimens and the work completed since on air-dry material has given the same general conclusion that the large variations in strength and specific gravity are between individual trees on the same site rather than between different geographical regions. They also indicate that material from Quality Class III sites gives the best compromise between a large volume and material of a reasonable quality.

The preliminary work reported last year on the effect of seed provenance on the quality of lodgepole pine has been completed and this indicated that provenance could have an effect on timber quality but that further sampling must be carried out to confirm this. Material of fifteen different provenances grown at Allerston Forest in North Yorkshire is now being sampled: some of these are grown from seed of the same origins as the Cloacanog material tested previously. Although the experimental work has not been completed there are indications that there is some interaction between site and provenance. This is illustrated by the fact that the same provenances do not necessarily produce the best quality material on both sites. Generally the material grown at Allerston appears to be appreciably denser than that from Cloacanog.

An investigation has been started to compare the strength and specific gravity of European and Japanese larch grown in the British Isles. It is proposed to sample both these species from eight different sites to see if there are any significant differences between their properties. So far material from three sites has been sampled. The results are inconclusive and indicate a big site effect. Thus on one site European larch gave the highest specific gravity and strength values whereas another showed Japanese larch equally superior and a third site showed little difference between them. The investigation is continuing.

Four consignments of Scots pine from Bagshot have been tested to study the effects of different thinning treatments on the quality of the timber. There was a slight tendency for the heavily thinned material to be less dense and strong than the lightly thinned material.

Home-grown timbers will probably be increasingly used for purposes where their resistance to nail withdrawal is of some importance (e.g. packaging and fencing). To provide data on the comparative resistance of home-grown timbers to nail withdrawal and also to examine some of the factors affecting such resistance this property is now being examined whenever a general assessment of timber quality is required. Static and impact nail withdrawal tests are carried out using 2 inch×12 gauge nails driven to a depth of one inch in the radial, tangential and end surfaces of the material. Two nails are driven into each surface of each specimen in the green condition, one being withdrawn immediately. The specimens are then dried to about 12 per cent moisture content and the second nail is then withdrawn. A third nail is then driven into each surface of the dry specimens and then withdrawn immediately.

Table 4 below gives average values obtained for some of the home-grown species tested.

Table 4

Average results of static nail withdrawal tests using 2 in. $\times$ 12 gauge round-wire nails embedded to a depth of 1 in.

Species	Nominal specific gravity	Moisture condition		Maximum resistance to withdrawal (lb)		
		When nailed	At test	Radial surface	Tangential surface	End surface
Sitka spruce	0.322	green	green	77	84	35
	"	green	dry	45	51	61
	"	dry	dry	67	91	49
Lodgepole pine	0.363	green	green	64	72	37
	"	green	dry	31	42	65
	"	dry	dry	57	70	51
American red oak	0.593	green	green	188	171	127
	"	green	dry	96	99	146
	"	dry	dry	275	221	149

These results show that with the two softwoods, nails driven into the tangential face give a higher withdrawal load than those in the radial face. There is little difference between the resistance to withdrawal in the green and dry condition if withdrawn immediately but if nailed green and allowed to dry there is a considerable reduction in strength on nails driven in the side grain and an appreciable increase for end grain penetration. The reduction in strength resulting from drying on nails driven into side grain shows the advantages of carrying out nailing as near as possible to the moisture contents likely to be attained in service.

WORKING STRESSES

Basic and working stresses for home-grown softwoods and a few imported species were published in 1956 followed by similar information on hardwoods. Since then additional information has been obtained and there has been a demand for stresses for other species. Moreover, a rapid increase in the use of laminated timber has created a need for basic stresses for dry timber in addition to the green values used in solid timber design. A revised version of the laboratory's information on working stresses has therefore been published²⁷. The result of tests on small clear specimens of timber, while enabling comparison between species cannot be used directly as safe working stresses necessary in structural design. This bulletin, which supersedes Bulletin 37, shows how basic and working stresses may be derived from these results. The method employed takes into account the natural variability in the strength of timber, and a safety factor is used to ensure that under all conditions of use the stress imposed on a member is a safe one. Permissible working stresses for two grades of timber, both green and air-dry, are derived for the species most likely to be available for structural use in this country.

LAMINATED CONSTRUCTION

During the year a start has been made on a study of the size and incidence of knots in commercial samples of redwood, a species that is being increasingly used for structural laminating in Britain. From this study it will be

possible to compare limiting "knot-ratios" determined from different samples of timber and to assess the effect of thickness on their frequency distributions. This basic information is needed to determine whether or not the same stress modification factors can be applied to all the softwood species commonly used for structural work. If general modification factors can be used then the resulting simplification will be of considerable practical importance.

To demonstrate the advantages to be gained by laminating, a composite structure was designed and constructed. This was made from a number of species of home-grown softwoods and as well as demonstrating that they can be just as effectively used for laminated work as the imported timbers it shows that clear material is not an essential requirement and that the limited size of sawn timber imposes no restriction on the size or shape of a laminated structure. The composite structure, shown in Plate 6, was exhibited by the Forestry Commission at the Royal Counties Centenary Show at Windsor.

TEXTURED CONCRETE

Considerable interest is being shown by architects and contractors in the production of *in situ* cast concrete with a raised surface texture. While this can be obtained by using shutter panels made from well-weathered imported Douglas fir difficulties are likely to be encountered in obtaining adequate supplies of suitable boards. A method has been devised, using a blunt jointed cutter block, for machining boards so as to give them a surface which will impart a prominent texture to the concrete (see Plate 7). An article describing this process and dealing with some of the problems associated with the use of timber shuttering and the drafting of specifications for formwork has been submitted for publication²⁸.

SHEET MATERIALS

An investigation into the methods of testing fibre building boards and the evaluation of their strength and associated properties has been started. This work, which forms part of the general programme of research into the properties of all-wood based sheet materials, has been extended to include a critical examination of a proposed International Standard of fibre boards and a comparison with British Standards. A study is being made of the methods of sampling the material, the effect of rate of loading, moisture content and size and shape of test specimens. Preliminary tests have been completed and the work is continuing.

EFFECT OF PRE-COMPRESSION ON STRENGTH

Because of the difference in magnitude of the ultimate tension and compression strengths of timber the fibres in the compression region of a beam can buckle under smaller loads than those necessary to cause actual fracture. It is generally assumed that beams with visible compression creases, or zones of buckled fibres, will have been weakened and should not therefore be used where strength is important. This assumption has however been challenged recently and evidence of tests has been produced to show that there is in fact no loss in strength. To obtain further information on this point a series of bending tests has been made on selected samples of Douglas fir, Sitka spruce and noble fir. These tests showed that although the presence of compression creases may not be significant under static loading they certainly do cause serious loss in strength under impact loading and a reversal of stress. For many uses particular care must therefore be exercised to exclude material containing compression creases.

WOODWORKING

COMPARISON OF TOOL WEAR

The measurement of the bluntness of worn cutting edges is a problem of considerable importance. The method of comparison described in last year's annual report, p. 15, depended on the measurement of the recession of the blunted edge from its position when sharp; this proved satisfactory for use with edges of short length, such as saw teeth, which are buried wholly in the wood during cutting. It is not suitable, however, for use with fairly long edges which have suffered localized blunting such as that caused by a glue line.

In a number of tests, carried out to compare the blunting effect of glue lines formed by various urea adhesives, it was found that the wear suffered by the cutting edge of a planer knife took the form of a prominent groove flanked on either side by a smaller amount of wear which decreased outwards from the groove (see Plate 8). In comparison with the thickness of the glue line, the cutting edge abraded by the glue is fairly long. Measurements showed that, whereas the thickness of the glue lines was of the order of 0.001 inch, the widths of the main groove worn in the cutter and of the total length of cutting edge abraded by the glue were about 0.010 inch and 0.025 inch respectively. Curry²⁹ has shown that dense layers of wood, partly compressed and impregnated with adhesive, exist on both sides of a glue line and that the glue also penetrates the wood in places for relatively large distances beyond these layers. Comparison shows that the width of the groove worn in a cutter corresponds with the total distance covered by the two densified layers of wood and the glue line, and that the wear on either side of the groove is caused by the intermittent cutting of glue which has penetrated further into the wood.

With different glues, there is some variation in the thickness of the two densified layers of wood and in the extent of the irregular penetration of the glue beyond these layers. The profile of the blunted cutting edge shows a corresponding change of form. As these factors should be taken into account in any assessment of cutter wear made with the object of comparing the blunting effect of different glues, the total area of the metal worn from the front face of the tool was taken as the measure of the cutter wear. This area was measured on magnified silhouettes of the blunt tool, such as those in Plate 8, where the position occupied by the original sharp edge is indicated by the pecked line.

WOODWORKING PROPERTIES

Home-grown softwoods. An investigation has been made into the effect of thinning treatment and of the position of timber in the height of the tree, on the planing and sawing properties of Scots pine. The trees were 73 years old and had been grown on one site, in four plots thinned to different grades. A preliminary analysis of the results shows that the specific gravity of the timber tested varied with its position in the tree. It was highest in the butt and lowest at the top and the power absorbed in sawing also followed this trend. Neither the thinning treatments nor the position of the timber in the height of the tree appeared to have any marked effect on the amount of tearing that occurred in planing.

Limited tests have been undertaken to determine the sawing and machining properties of some lodgepole pine grown under park conditions, and also of the species *Pinus holfordiana*.

Boring of home-grown ash. In the course of previous tests to establish relationship between torque and thrust when other drill parameters were varied, a small but consistent difference in the force readings was observed when boring samples taken from various positions along the length of the tree. It was possible to check these findings when material became available from some consignments of European ash. Quadrants were cut from top, mid and butt positions in several logs and sticks taken from each quadrant in matching positions relative to the growth rings. The sticks were then converted to 2 inch $\times$ 2 inch boring blocks.

Using a 1 inch Scotch nose bit, torque and thrust readings were obtained from each block. The experiment was designed for statistical analysis and the results showed that the readings of torque and thrust for specimens from different heights in the trees decreased steadily from top through mid to the butt position; this difference in the readings was statistically significant at the 10 per cent level.

STRESSES IN CIRCULAR SAWS

Some progress has been made with the research begun last year to determine the stresses in circular saws and to investigate the effect of tooth design on the heating of the blade in cutting. Stresses are induced in the saw by the hammering it receives in the so-called tensioning process, by the radial temperature differential set up in the blade by the cutting action of the teeth, and by the forces of rotation.

Tensioning. A preliminary study made to obtain some idea of the value and distribution of the stresses due to hammering has given the results shown in Curve A, Fig. 5. The curve represents the distribution of the tangential stresses in a 26-inch diameter saw after it had received the normal amount of hammering to prepare it for use. It appears that the distribution of the stress is generally similar to that found in a compound cylinder formed by the

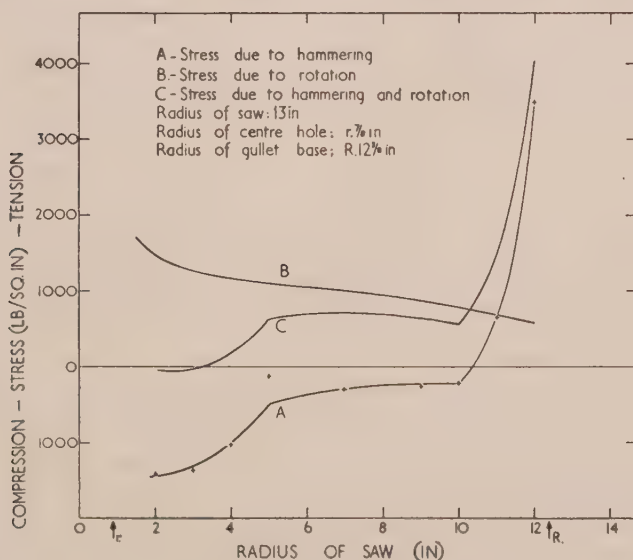


Fig. 5. Tangential stresses in a circular saw

successive shrinking of three cylinders one on the other. The stress in the outer annulus of the saw was found to increase more quickly and to reach higher values than is generally supposed. Curve B shows the calculated tangential stresses due to the rotation of the saw and Curve C the combined effects of hammering and rotation.

In this study, the hammered stresses in a saw were calculated from changes which occurred in electric strain gauge measurements after the tension in the blade had been released by careful hammering round its rim. The degree to which the tension had been released was assessed by the method used by saw doctors, namely by estimating the drop of the blade from a horizontal straight edge. With these practical methods of releasing tension and estimating the condition of a saw, it is not possible to judge exactly when the blade is free from stress, so the values of stress measured can only be regarded as approximate. The metal in a circular saw could be restored to a stress-free condition by dividing the saw into a number of small segments and the changes in strain occurring within such segments should provide a good estimate of the hammered stresses in the blade. Ideally, the division of the saw should be accomplished without the generation of excessive heat, as this tends to release the stresses prematurely, and without bending or twisting of the blade. Experiments using a controlled flow of acid solution have shown promise in meeting these requirements.

Heating. Methods of measuring the temperatures attained by the surface of the saw blade and by the teeth during cutting have also been explored. The temperature measuring device used should not interfere with the working of the saw and must be robust enough to travel with the blade through the wood being cut. The most promising appears to be a thermocouple junction between the saw and a fine insulated constantan wire; the wire is glued to the saw surface and protected by a thin film of epoxy resin. The electrical outputs from such thermocouples are taken out through a multiple slip-ring assembly and displayed on a cathode ray tube. It was found that the rotation of the saw in the complex magnetic system of the iron frame of the saw bench impressed a relatively large alternating voltage on the output of the thermocouple and made reliable temperature measurement impossible. A wooden-framed saw bench is being built, in which this difficulty should not arise.

THEORY OF CUTTING

Rectilinear cutting. The effect of grain orientation on the cutting forces has been studied on the low-speed machine. A series of tests, in which the angle of the line of cut to the direction of the growth rings has been varied within the range 90° (end-grain cutting) to 0° (parallel to, and along, the grain) shows that the cutting forces decrease as the angle is reduced from 90° to 40° .

On the high-speed machine a short study has been made of the reduction in chip length which occurs at certain cutting angles. Micro-density determinations on the chips show that the decrease of length is entirely taken up within the cell spaces: no thickening of the chip (such as occurs in metal cutting) was found.

Rotary cutting. Further investigations have been made using the experimental rig referred to in last year's annual report p. 16. These examined the effect of an increase in mean chip thickness on the cutting forces parallel to and perpendicular to the cut surface. The tests have shown that the maximum

forces exerted by the cutter when detaching the chip occur immediately after the position in its travel at which maximum chip thickness occurs. The magnitudes of the forces increase linearly as the chip thickness is increased. This is in agreement with results obtained from power measurements on a commercial planing machine³⁰.

REFERENCES

1. WISE, L. E. and JAHN, E. C. Wood Chemistry. New York, Reinhold, 1952. II, 1274.
2. BRASCH, D. J. and JONES, J. K. N. The Structure of an Arabinogalactan from Monterey Pine (*Pinus radiata*). *Can. J. Chem.*, 1959, **37**(9), 1538-1545.
3. BOUVENG, H. D. and LINDBERG, B. Fractionation of the Arabinogalactan from *Larix occidentalis* Nutt. *Acta Chem. Scand.*, 1958, **12**(10), 1977-1984.
4. MUSGRAVE, M. J. P. Calculations Relating to the Propagation of Elastic Waves in Anisotropic Media. *Rep. nat. phys. Lab., Basic Physics Divn.*, 1961, No. 7, H.M.S.O.
5. TEFFT, W. L. Numerical Solution of the Frequency Equations for the Flexural Vibration of Cylindrical Rods. *J. Res. Nat. Bur. Stand.*, 1961, **64B**(4), 237-242.
6. BRITISH STANDARDS INSTITUTION. Wood Poles for Overhead Lines. *Brit. Stand. Spec.*, 1990: 1953.
7. SMITH, D. N. and COCKCROFT, R. The Preservative Treatment of Home-grown Timbers by Diffusion. *Wood*, 1961, **26**(12), 490-492.
8. GRIFFITHS, R. J. and COCKCROFT, R. Neutron Absorption Estimation of Boron Preservatives in Timber. *J. Inst. Wood Sci.* 1961, (7), 73-77.
9. SMITH, D. N. The Natural Durability of Timber. *Rec. For. Prod. Res.*, 1959, No. 30, H.M.S.O.
10. PURSLOW, D. F. The Effect of Specimen Size on the Life of Timber in Contact with the Ground. *Wood*, 1962, **27**(3), 99-100.
11. BRITISH STANDARDS INSTITUTION. Method of Test for the Toxicity of Wood Preservatives to Fungi. *Brit. Stand. Spec.* 838: 1961.
12. VAATAJA, O. Selectivity of Fungicidal Materials in Agar Cultures. *Phytopathology*, 1960, **50**(12), 870-873.
13. BLECHLY, J. D. and TAYLOR, JEAN M. Methods of Testing Preservatives against the Common Furniture Beetle (*Anobium punctatum* Deg.) and the House Longhorn Beetle (*Hylotrupes bajulus* L.) at the Forest Products Research Laboratory. *J. Inst. Wood Sci.*, 1961, (8), 4-11.
14. FISHER, R. C. and TASKER, H. S. The Detection of Wood-boring Insects by Means of X-rays. *Ann. appl. Biol.*, 1940, **27**(1), 92-100.
15. JACQUIOT, C. L'Utilisation des Rayons X dans les Recherches et les Essais sur les Insectes Xylophages. *Corros. Anticorros.*, 1960, **9**(3), 74-79.
16. PRATT, G. H. Report on a Preliminary Investigation into the Accelerated Air-drying of Home-grown Pitprops. Princes Risborough, F.P.R.L., 1961.
17. STUTZ, R. E. Control of Brown Stain in Sugar Pine with Sodium Azide. *For. Prod. J.*, 1959, **9**(12), 459-463.

18. JOHNSTON, D. D. and BAUD, M. J. The Effect of Mechanical Restraint During Drying on the Subsequent Distortion of Timber. The Influence of Over-drying and Re-wetting before Release of Restraint. Princes Risborough, F.P.R.L., 1961.
19. DEAN, A. R. The Effect of Longitudinal Compression Treatments on the Bending and other Mechanical Properties of European Beech, Part I. Princes Risborough, F.P.R.L., 1961.
20. KNIGHT, R. A. G. and SOANE, G. E. Durability of Glues for Plywood Manufacture. *Investigation into Glues and Gluing, Prog. Rep.* 125, Princes Risborough, F.P.R.L., 1961.
21. CARRUTHERS, J. F. S. and PAXTON, B. H. A Study of the Function of Pressure and some Associated Factors in the Gluing of Wood. Part II The Effect of Glue Type. *Investigation into Glues and Gluing, Prog. Rep.* 124. Princes Risborough, F.P.R.L., 1960.
22. CARRUTHERS, J. F. S. The Ageing of Radio Frequency Set Glued Joints. *Radio Frequency and Other Heating Processes, Prog. Rep.* 20. Princes Risborough, F.P.R.L., 1960.
23. CARRUTHERS, J. F. S. and PAXTON, B. H. The Performance of some Synthetic Resin Glues under Radio Frequency Heating. *Radio Frequency and Other Heating Processes, Prog. Rep.* 17. Princes Risborough, F.P.R.L., 1958.
24. CARRUTHERS, J. F. S., PAXTON, B. H., and BURRIDGE, M. S. The Efficiency of Radio Frequency Heating for Glue Setting in Wood Joints. Part I. The Derivation of the Power Equations and the Measurement Technique. *Radio Frequency and Other Heating Processes, Prog. Rep.* 19. Princes Risborough, F.P.R.L., 1960.
25. NEWALL, R. J. and GROSE, G. E. Bark Form and Veneer Figure in Home-grown Birch. *Trials of Timber for Plywood Manufacture, Prog. Rep.* 57. Princes Risborough, F.P.R.L., 1961.
26. SUNLEY, J. G. and LAVERS, GWENDOLINE M. Variations in the Strength and Specific Gravity of Sitka Spruce Grown in Great Britain. *J. Inst. Wood Sci.*, 1961, (7), 15-27.
27. SUNLEY, J. G. Working Stresses for Structural Timbers. *Bull. For. Prod. Res., Lond.*, 1961, No. 47. H.M.S.O.
28. CURRY, W. T. Timber Shuttering to give Textured Concrete. *Civ. Engng., Lond.*, 1962, 57(666), 93, 95, 97.
29. CURRY, W. T. The Strength Properties of Plywood. Part 3 The Influence of the Adhesive. *Bull. For. Prod. Res., Lond.*, 1957, No. 39. H.M.S.O.
30. GOODCHILD, R. Power Requirements in Rotary Planing. Princes Risborough, F.P.R.L., 1958.

A. C. COPISAROW,

Director.

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Aylesbury, Bucks.

January, 1962.

APPENDIX I

STAFF OF THE FOREST PRODUCTS RESEARCH LABORATORY

31st December, 1961

Director of Forest Products Research: A. C. Copisarow, D.Sc., F.Inst.P.,
A.M.I.E.E., F.I.W.Sc.

ADMINISTRATION

Deputy Director: J. Bryan, M.Eng., A.M.I.C.E.

Higher Executive Officer: J. D. Bingham.

Executive Officer: H. T. Johnson.

EXTERNAL RELATIONS SECTION

Principal Scientific Officer: F. G. O. Pearson, B.Sc. (Officer in Charge).

Senior Experimental Officer: A. V. Thomas, M.Eng.

Experimental Officer: Miss C. Webster.

Assistant Experimental Officer: D. C. Bedding.

INTELLIGENCE SECTION

Principal Scientific Officer: B. J. Rendle, B.Sc., A.R.C.S., F.L.S., F.I.W.Sc.,
(Officer in Charge).

Senior Experimental Officer: A. J. Foord.

Experimental Officer: J. A. H. Broughton, B.Sc., A.I.W.Sc.

Assistant Experimental Officer: T. Harding.

DIVISION A (SCIENCE)

Senior Principal Scientific Officer: E. J. Gibson, B.Sc., Ph.D., A.R.I.C. (Divisional
Head).

WOOD STRUCTURE SECTION

Principal Scientific Officer: E. W. J. Phillips, B.Sc., Ph.D., A.R.C.S., F.I.W.Sc.
(Officer in Charge).

Senior Scientific Officer: J. D. Brazier, B.Sc.

Experimental Officers: G. L. Franklin; D. G. Patterson, M.Sc.

CHEMISTRY SECTION

Principal Scientific Officers: R. H. Farmer, B.A., B.Sc., D.Sc.(Tech.), F.R.I.C.,
F.I.W.Sc. (Officer in Charge).

R. A. Laidlaw, B.Sc., Ph.D.

Senior Scientific Officer: J. W. W. Morgan, B.Sc., Ph.D., A.R.I.C.

Experimental Officer: L. C. Pinion, B.Sc.

Assistant Experimental Officer: G. A. Smith.

PHYSICS SECTION

Principal Scientific Officer: R. F. S. Hearmon, F.Inst.P., F.I.W.Sc.
(Officer in Charge).

Experimental Officers: E. H. Adams; J. McC. Paton.

PULP AND PAPER SECTION

Senior Principal Scientific Officer: E. J. Gibson, B.Sc., Ph.D., A.R.I.C. (Officer in Charge).
Research Fellow: J. M. Dinwoodie, B.Sc., Ph.D., A.I.W.Sc.
Senior Experimental Officer: D. F. Packman, B.E.M.
Assistant Experimental Officer: R. J. Orsler.

WOOD PRESERVATION SECTION

Principal Scientific Officer: D. N. R. Smith (Officer in Charge).
Experimental Officers: R. Cockcroft, A.I.W.Sc.; Miss E. Lee; D. F. Purslow, B.Sc.; L. W. Redding.

MYCOLOGY SECTION

Principal Scientific Officer: J. G. Savory, B.Sc., M.Inst.Biol., F.I.W.Sc. (Officer in Charge).
Senior Scientific Officer: R. S. Smith, B.Sc., Ph.D., D.I.C.
Experimental Officer: E. C. Badcock.
Assistant Experimental Officer: J. S. Lawrence, B.Sc.

ENTOMOLOGY SECTION

Principal Scientific Officer: J. D. Bletchly, T.D., B.A., B.Sc., F.R.E.S., M.Inst.Biol., F.I.W.Sc. (Officer in Charge).
Senior Scientific Officers: J. M. Baker, B.Sc., M.Inst.Biol.; M. G. White, M.A., F.R.E.S.
Senior Experimental Officer: E. C. Harris, F.R.E.S.
Experimental Officer: Miss J. M. Taylor, B.Sc., M.Inst.Biol.

DIVISION B (ENGINEERING)

Senior Principal Scientific Officer: F. H. Armstrong, M.Sc., M.I.Mech.E., F.I.W.Sc. (Divisional Head).

SEASONING SECTION

Principal Scientific Officer: W. C. Stevens, M.A., A.M.I.Mech.E., F.I.W.Sc. (Officer in Charge).
Senior Experimental Officers: R. E. Hodge, Assoc.I.Mech.E., A.I.W.Sc.; D. D. Johnston, A.I.W.Sc.; G. H. Pratt; N. Turner.
Experimental Officer: A. R. Dean.
Assistant Experimental Officers: M. J. Baud; G. A. Bennett; R. H. Wynands.

COMPOSITE WOOD SECTION

Principal Scientific Officers: R. A. G. Knight, B.Sc.(Eng.), M.I.Mech.E., F.I.W.Sc. (Officer in Charge).
 J. F. S. Carruthers, B.Sc., A.M.I.Mech.E.
Senior Experimental Officers: L. S. Doman; R. J. Newall.
Experimental Officer: R. W. Hudson.
Assistant Experimental Officers: B. H. Paxton, B.Sc., Grad.Inst.P.
 M. S. Burrridge.

TIMBER MECHANICS SECTION

Principal Scientific Officers: J. G. Sunley, M.Sc. (Officer in Charge);
 W. T. Curry, A.I.W.Sc.
Senior Scientific Officer: A. J. Comben, B.Sc.*
Experimental Officers: G. R. Brock; W. T. Hide; Miss G. M. Lavers.
Temporary Experimental Officer: Mrs. W. M. Hudson.
Assistant Experimental Officer: S. A. Covington.

* Seconded to Government of Federation of Nigeria 14th September, 1961.

WOODWORKING SECTION

Principal Scientific Officer: K. J. S. Walker, M.A., A.M.I.Mech.E.
(Officer in Charge).

Senior Experimental Officers: H. J. Endersby; R. Goodchild, A.I.W.Sc.

DRAWING OFFICE

Experimental Officer: E. A. Steel, Assoc.I.Mech.E.

PHOTOGRAPHY

Senior Photographer: W. J. Baldwin.

APPENDIX II

LIST OF PUBLICATIONS ISSUED DURING 1961

A. STATIONERY OFFICE PUBLICATIONS

FOREST PRODUCTS RESEARCH, 1960.

Bulletins:

- No. 46 Identification of Hardwoods. A Microscope Key. By J. D. Brazier, B.Sc., and G. L. Franklin.
- No. 47 Working Stresses for Structural Timbers. By J. G. Sunley, M.Sc.

Leaflets:

- No. 47 The Movement of Timbers. (*Revised Edition*)

Record:

- No. 31 Non-pressure Methods of Applying Wood Preservatives. By J. Bryan, M.Eng., A.M.I.C.E., and D. F. Purslow, B.Sc.

Special Report:

- No. 15 Working Stresses for Structural Laminated Timber. By W. T. Curry.

B. OTHER PUBLICATIONS

BLETCHLY, J. D. A Review of Factors Affecting Ambrosia Beetle Attack in Trees and Felled Logs. *Emp. For. Rev.*, 1961, **40**(1), 13-18.

BLETCHLY, J. D. The Effect of γ -radiation on Some Wood-boring Insects. *Ann. appl. Biol.*, 1961, **49**, 362-370.

BLETCHLY, J. D. Effect of a Sub-lethal Dosage of Gamma Radiation on a Population of *Lyctus brunneus* Steph. (Col. Lyctidae). *Proc. R. ent. Soc. Lond.*, 1961, Series C, **26**(2), 5.

BLETCHLY, J. D. and TAYLOR, JEAN M. Methods of Testing Preservatives Against the Common Furniture Beetle (*Anobium punctatum* Deg.) and the House Long-horn Beetle (*Hylotrupes bajulus* L.) at the Forest Products Research Laboratory. *J. Inst. Wood Sci.*, 1961, (8), 4-11.

CARRUTHERS, J. F. S. and HUDSON, R. W. Varying Moisture Content of Mechanically Dried Veneers. *For. Prod. J.*, 1961, **11**(7), 293-296.

CURRY, W. T. Stress Values for Laminated Timber. Relaxing Quality Standards by Determining Realistic Values. *Timb. Tr. J.*, 1961, **237**(4422), 69-71.

ENDERSBY, H. J. Sawing of Wood. *Research*, 1961, **14**(4), 126-130.

ENDERSBY, H. J. Stresses in Circular Saws. *Timb. Tr. J.*, 1961, **238**(4430), 73, 75.

GRIFFITHS, R. J. and COCKCROFT, R. Neutron Absorption Estimation of Boron Preservatives in Timber. *J. Inst. Wood Sci.*, 1961, (7), 73-77.

HARRIS, E. C. Kiln and Air Drying of European Oak: Effect on Starch Depletion and Consequent Susceptibility to Lyctus Attack. *J. Inst. Wood Sci.*, 1961, (7), 3-14.

HARRIS, E. C. The Value of Fumigation for the Control of Wood-boring Insects. *Proc. R. ent. Soc. Lond.*, 1961, Series C, **26**(2), 6.

- HUDSON, WINIFRED M. The Effect of Pre-compression on the Static and Impact Bending Strength of Wood. *Wood*, 1961, **26**(1), 18-20.
- LAIDLAW, R. A., FARMER, R. H. and SMITH, G. A. The Polysaccharides of European Beech (*Fagus sylvatica*). A Preliminary Survey. *Holzforschung*, 1961, **15**(1), 15-18.
- PEARSON, F. G. O. and FIELDING, HAZEL A. Some Properties of Individual Growth Rings in European Larch and Japanese Larch and Their Influence Upon Specific Gravity. *Holzforschung*, 1961, **15**(3), 82-89.
- PURSLOW, D. F. The Preservation of Timber Used Out of Doors. *Ill. Carp. Build.*, 1961, **150**(4400), 4173.
- SAVORY, J. G. and COCKCROFT, R. Anti-stain Treatments. Failure in Some Parcels of Imported Timber. *Timb. Tr. J.*, 1961, **239**(4440), 67-68, 72.
- SMITH, D. N. and COCKCROFT, R. A Method of Obtaining Uniform Distribution of Wood Preservatives in Toxicity Test Blocks. *Nature*, 1961, **189**(4759), 163-164.
- SMITH, D. N. and COCKCROFT, R. The Preservative Treatment of Home-grown Timber by Diffusion. *Wood.*, 1961, **26**(12), 490-492.
- STEVENS, W. C. Rates of Change in the Dimensions and Moisture Contents of Wooden Panels Resulting From Changes in the Ambient Air Conditions. *Studies in Conservation*, 1961, **6**(1), 21-25.
- STEVENS, W. C. and JOHNSTON, D. D. The Seasoning Properties of Home-Grown *Prod. J.*, 1961, **11**(8), 348-356.
- STEVENS, W. C. Accelerated Air-drying and Pre-drying of Timber. An Appreciation of Various Methods Used. *Timb. Tr. J.*, 1961, **239**(4446), 83-85.
- STEVENS, W. C. and JOHNSON, D. D. The Seasoning Properties of Home-grown Sitka Spruce. *J. Inst. Wood Sci.*, 1961, (7), 28-33.
- STEVENS, W. C. and TURNER, N. Ash Hockey Stick Bends. *Wood*, 1961, **26**(10), 417-419.
- STEVENS, W. C. and TURNER, N. Experiments With Flexible Wood. *Wood*, 1961, **26**(11), 444-445.
- SUNLEY, J. G. and LAVERS, GWENDOLINE, M. Variations in the Strength and Specific Gravity of Sitka Spruce Grown in Great Britain. *J. Inst. Wood Sci.*, 1961, (7), 15-27.
- TAYLOR, JEAN M. The Use of Contact Insecticides for the Control of Certain Wood-boring Insects.. *Rec. 1961 Ann. Conv., Br. Wood Pres. Ass. (In the press)*.
- TAYLOR, JEAN M. Laboratory Technique for Testing Wood Preservatives. *Pest Technol.*, 1961, **3**(9), 210-211, 215.
- WALKER, K. J. S. The Angle of Dovetail Joints. *Woodworking Ind.*, 1961, **18**(11), 644-645.

APPENDIX III

LIST OF COMMON NAMES CITED IN THE TEXT

Abura	<i>Mitragyna ciliata</i>
African mahogany	<i>Khaya</i> spp.
Afrormosia	<i>Afrormosia elata</i>
American red oak	<i>Quercus</i> spp.
Ash	<i>Fraxinus excelsior</i>
Ash, European	<i>Fraxinus excelsior</i>
Beech	<i>Fagus sylvatica</i>
Birch	<i>Betula</i> spp.
Boxwood, Knysna	<i>Gonioma kamassi</i>
Boxwood, Maracaibo	<i>Gossypiospermum praecox</i>
Cedar of Lebanon	<i>Cedrus libani</i>
Corsican pine	<i>Pinus nigra</i> var. <i>calabrica</i>
Douglas fir	<i>Pseudotsuga taxifolia</i>
European ash	<i>Fraxinus excelsior</i>
European larch	<i>Larix decidua</i>
European oak	<i>Quercus robur</i> and <i>Q. petraea</i>
European spruce	<i>Picea abies</i>
Fir, Douglas	<i>Pseudotsuga taxifolia</i>
Fir, Noble	<i>Abies procera</i>
Greenheart	<i>Ocotea rodiaei</i>
Hickory	<i>Carya</i> spp.
Hornbeam	<i>Carpinus betulus</i>
Horse-chestnut	<i>Aesculus hippocastanum</i>
Indian rosewood	<i>Dalbergia latifolia</i>
Japanese larch	<i>Larix leptolepis</i>
Knysna boxwood	<i>Gonioma kamassi</i>
Larch	<i>Larix</i> spp.
Larch, European	<i>Larix decidua</i>
Larch, Japanese	<i>Larix leptolepis</i>
Lodgepole pine	<i>Pinus contorta</i>
Mahogany, African	<i>Khaya</i> spp.
Maracaibo boxwood	<i>Gossypiospermum praecox</i>
Niangon	<i>Tarrietia utilis</i>
Noble fir	<i>Abies procera</i>

Oak	<i>Quercus</i> spp.
Oak, American red	<i>Quercus</i> spp.
Oak, European	<i>Quercus robur</i> and <i>Q. petraea</i>
Oak, Turkey	<i>Quercus cerris</i>
Obeche	<i>Triplochiton scleroxylon</i>
Pine, Corsican	<i>Pinus nigra</i> var. <i>calabrica</i>
Pine, Lodgepole	<i>Pinus contorta</i>
Pine, Radiata	<i>Pinus radiata</i>
Pine, Scots	<i>Pinus sylvestris</i>
Pine, Sugar	<i>Pinus lambertiana</i>
Pine, Yellow	<i>Pinus strobus</i>
Podo	<i>Podocarpus</i> spp.
Purpleheart	<i>Peltogyne</i> spp.
Pyinkado	<i>Xylia dolabriformis</i>
Radiata pine	<i>Pinus radiata</i>
Redwood	<i>Pinus sylvestris</i>
Rosewood, Indian	<i>Dalbergia latifolia</i>
Scots pine	<i>Pinus sylvestris</i>
Seraya, Yellow	<i>Shorea</i> spp.
Sitka spruce	<i>Picea sitchensis</i>
Spruce, European	<i>Picea abies</i>
Spruce, Sitka	<i>Picea sitchensis</i>
Sugar pine	<i>Pinus lambertiana</i>
Teak	<i>Tectona grandis</i>
Turkey oak	<i>Quercus cerris</i>
Utile	<i>Entandrophragma utile</i>
Yellow pine	<i>Pinus strobus</i>
Yellow seraya	<i>Shorea</i> spp.
Yew	<i>Taxus baccata</i>

INDEX

- Abura
 - kiln drying, 25
- Adhesives
 - blunting effect on cutters, 32
 - durability, 27
 - R.F. heating, 28
 - setting conditions, 27
 - tests, 27
- Advisory work, 6
- African mahogany
 - plywood, 27
- Afromosia
 - kiln drying, 25
- Ambrosia beetle, *see* Insects, *Trypodendron lineatum*
- American red oak
 - kiln drying, 25
 - nail withdrawal test, 29, 30
- Ash
 - boring, 33
 - elasticity, 14
- Atomic Energy Authority, 4
- Beech
 - Anobium* attack, 21
 - bending, 26, 27
 - discoloration, 5, 26
 - plywood, 27
 - seasoning, 6, 25
- Bending, *see* Wood bending
- Beta particle equipment, 7, 13
- Birch
 - bark form and veneer figure, 28
- Blue stain, *see* Fungi, Sap stain
- British Plastics Federation, 4, 28
- British Broadcasting Corporation, 5
- British Standards Institution, 4
- Building Exhibition, Olympia, 7
- Building Research Station, 5, 18, 19
- Bungalow construction, 7
- Cedar of Lebanon
 - kiln drying, 25
- Cedar, Western red, *see* Western red cedar
- Centre Technique du Bois, 6
- Centre Technique Forestier Tropical, 6
- Central Office of Information, 5, 7
- Chemistry
 - extractives, 12
 - nitrogenous studies, 11, 12
 - polysaccharides, 12
 - pulping studies, 15
- Chipboard, 1, 4, 6, 28
- Collections
 - cultures, 19
 - timber specimens, 9, 10
 - wood-boring insects, 25
- Common furniture beetle *see* Insects *Anobium punctatum*
- Commonwealth Forestry Institute, 10
- Composite Wood Panel, 4, 5
- Composite Wood Research Panel, 4
- Corsican pine
 - Anobium* attack, 21
 - water vapour diffusion, 13
- Death-watch beetle, *see* Insects, *Xestobium rufovillosum*
- Density determination
 - beta-ray 7, 13
 - liquid displacement, 13
- Department of Technical Co-operation, 1
- Douglas fir
 - density, 13
 - extractives, 12
 - nitrogen content, 11, 12
 - pre-compression, 31
 - shuttering, 31
- Dry rot, *see* Fungi, *Merulius lacrymans*
- Drying, *see* Seasoning
- Education, 6, 7
- Entomology, *see* Insects
- European ash, *see* Ash
- European larch
 - density, 13
 - extractives, 12
 - kiln drying, 25
 - natural durability, 19
 - strength and specific gravity, 29
- European lime
 - natural durability, 17

- European oak
 deterioration in "Vasa", 6
 elasticity, 14
 natural durability, 17
 nitrogen content, 11, 12
 preservation, 18
Xestobium attack, 23, 24
- European spruce
 elasticity, 14
 natural durability, 21
Urocerus attack, 24
- Exhibitions, 7
- Forest Department, Tanganyika, 10
- Forest Products Research Branch,
 Canada, 5
- Forest Products Research Laboratory,
 Nigeria, 1, 5
- Forestry Commission, 3, 4, 10, 16, 18,
 19, 24, 25, 28, 31
- Fumigation, 24
- Fungi,
Coniophora cerebella, 20, 21
Hormodendron resinae, 20
Merulius lacrymans, 19, 20
 Sap stain, 20, 23
Trichoderma viride, 20
- Fungicides, 20
- Gamma radiation, 25
- Glues, *see* Adhesives
- Grading, 6, 7
- Greenheart
 kiln drying, 25
- Hanover Fair, 6
- Hickory
 kiln drying, 25
- H.M.S. *Victory*, 24
- Hornbeam
 kiln drying, 25
- Horse-chestnut
 density, 13
- House longhorn beetle, *see* Insects,
Hylotrupes bajulus
- Houtinstitut, T.N.O., 6
- Imperial College of Science, 6
- Indian rosewood
 kiln drying, 25
- Insecticides
 control of *Trypodendron*, 24
 methyl bromide, toxicity to *Hylotrupes*, *Urocerus*, *Xestobium*, 24
- Insects
Anobium punctatum
 control, 24
 damage to buildings, 21
 nutrition, 4, 21
Hylotrupes bajulus
 control, 24
 distribution, 5, 21, 22
 larval growth, 23
Phytolyma lata, 5
Trypodendron lineatum
 control, 24
Urocerus gigas
 control, 24
Xestobium rufovillosum
 biological studies, 23
 control, 24
 gamma radiation, 24
- Intelligence Section, 3
- International Congress of Pure and
 Applied Chemistry, 6
- Iroko
 gall bug, 5
- Japanese larch
 extractives, 12
 kiln drying, 25
 natural durability, 19
 strength and specific gravity, 29
- Knysna boxwood
 density, 13
- Labótorio de Histologia e Tecno-
 logia de Madeiras, 9
- Larch
 extractives, 12
- Lodgepole pine
 kiln drying, 25
 nail withdrawal tests, 29, 30
 polysaccharides, 12
 pulping studies, 15
 quality studies, 10, 29
- Maracaibo boxwood
 kiln drying, 25
- Medical Research Council, 4
- Meteorological Office, 21
- Mycology, *see* Fungi
- National Engineering Laboratory, 5
- National Institute for Research in
 Nuclear Science, 16
- National Physical Laboratory, 14

- Natural durability
 sawdust, 19, 21
 specimen thickness, 17, 18
- Niangon
 kiln drying, 25
- Noble fir
 pre-compression, 31
- Oak
 kiln drying, 25
- Obeche
 nitrogen content, 12
- Physics
 density determination, 13
 elasticity, 14
 water vapour diffusion, 13
- Pinus holfordiana*
 quality studies, 10
 woodworking, 32
- Podo
 density, 13
- Preservation, *see also* Fungicides and
 Insecticides
 boron estimation, 16, 17
 diffusion studies, 15, 16
 permeability, 5, 18, 19
 treatment of poles, 15
 toxicity tests, 19, 23
- Publications, 7, 9, 40, 41
- Pulp and paper
 pulp quality, 4, 15
 sulphate cooking, 14
 sulphite cooking, 14, 15
- Purpleheart
 kiln drying, 25
- Pyinkado
 extractives, 12
- Radio Frequency Panel, 4
- Radio frequency heating, 28
- Radiata pine
 polysaccharides, 12
- Red oak, *see* American red oak
- Redwood
 natural durability, 17
 treatment of poles, 15
- Royal Counties Centenary Show,
 Windsor, 7, 31
- Royal Show, Cambridge, 7
- Royal Society, 7
- Sap stain, *see* Fungi
- Scots pine
 Anobium attack, 21
 Scots Pine—*contd.*
 anti-shrink treatment, 26
 Hylotrupes attack, 23
 strength, 29
 treatment of poles, 3, 15
 woodworking, 32
- Seasoning
 accelerated air-drying, 5, 25, 26
 distortion experiments, 26
 kiln drying, 25, 26
- Seraya, *see* Yellow seraya
- Sitka spruce
 Anobium attack, 21
 boron diffusion, 15, 16
 density, 13
 nail withdrawal test, 29, 30
 nitrogen content, 11
 "plus" trees, 10
 pre-compression, 31
 pulp studies, 14, 15
 quality studies, 10
 strength and specific gravity, 29
 Trypodendron attack, 24
- Smithsonian Institution, 9
- Spade handles, 3, 4, 27
- Staff, 9, 37-39
- Strength tests
 effect of pre-compression, 31
 fibre boards, 31
 glued joints, 28
 laminated structures, 30, 31
 working stresses, 30
- Sugar pine
 brown stain, 26
- Teak
 bending, 27
 kiln drying, 25
 natural durability, 19
- Textured concrete, 4, 31
- Timber Development Association, 5
- Timber Trade Federation, 5
- Tropical Products Institute, 14
- Turkey oak
 quality studies, 11
- Universities
 Bangor, 5
 Edinburgh, 5, 12
 Leeds, 5
 Nottingham, 5
 Oxford, 5, 7, 10
 University College, Dublin, 5
- Utile
 kiln drying, 25

- Visits overseas, 1, 6
Visitors to Laboratory, 7
- Western red cedar
 natural durability, 17
- Wood bending, 26, 27
- Wood wasp, *see* Insects, *Urocerus gigas*
- Woodworking
 boring, 33
 machining, 32
 sawing, 32
 sawmilling, 6
- Woodworking—*contd.*
 stresses in circular saws, 33
 theory of cutting, 34, 35
 tool wear, 32
- X-ray equipment, 25
- Yellow seraya
 kiln drying, 25
- Yew
 density, 13

FOREST PRODUCTS RESEARCH PUBLICATIONS

Annual Reports of the Forest Products Research Steering Committee and the Director of Forest Products Research:

Forest Products Research 1958	..	..	..	..	5s. 0d.	(5s. 5d.)
Forest Products Research 1959	..	..	..	..	5s. 6d.	(5s. 11d.)
Forest Products Research 1960	..	..	..	..	5s. 0d.	(5s. 5d.)

BULLETINS:

No. 1. Dry Rot in Wood. (6th Edition, 1960)	..	..	..	..	4s. 0d.	(4s. 4d.)
No. 20. Requirements and Properties of Adhesives for Wood. (3rd Edition, 1956)	..	..	..	..	2s. 0d.	(2s. 3d.)
No. 24. The Protection of Buildings and Timber against Termites. (1950)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 25. Identification of Hardwoods—A Lens Key. (2nd Edition, 1960)	..	..	..	..	7s. 6d.	(8s. 0d.)
No. 26. An Atlas of End-Grain Photomicrographs for the Identification of Hardwoods. (1953)	..	..	..	..	21s. 0d.	(21s. 9d.)
No. 27. The Performance of Circular Plate Ripsaws. (1953)	..	..	..	..	1s. 9d.	(2s. 0d.)
No. 29. The Strength Properties of Plywood—Part 1. Comparison of 3-Ply Woods of a Standard Thickness. (1953)	..	..	..	..	1s. 3d.	(1s. 6d.)
No. 30. Mechanics of Sawing: Band and Circular Saws. (1954)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 31. Prevention of Decay of Wood in Boats. (1954)	..	..	..	..	3s. 0d.	(3s. 4d.)
No. 32. Field Tests on Wood Preservatives used for Pressure Treatment. (1954)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 35. The Machine Boring of Wood. (1955)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 36. Meranti, Seraya and Allied Timbers. (1956)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 37. Working Stresses for Structural Softwoods. (1956)	..	..	..	..	1s. 3d.	(1s. 6d.)
No. 38. The Efficiency of Adhesives for Wood. (2nd Edition, 1959)	..	..	..	..	3s. 0d.	(3s. 4d.)
No. 40. Timbers for Flooring. (1957)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 41. The Strength of Nailed Joints (1957)	..	..	..	..	2s. 6d.	(2s. 10d.)
No. 42. The Strength Properties of Plywood—Part 4. Working Stresses. (1957)	..	..	..	..	2s. 0d.	(2s. 4d.)
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